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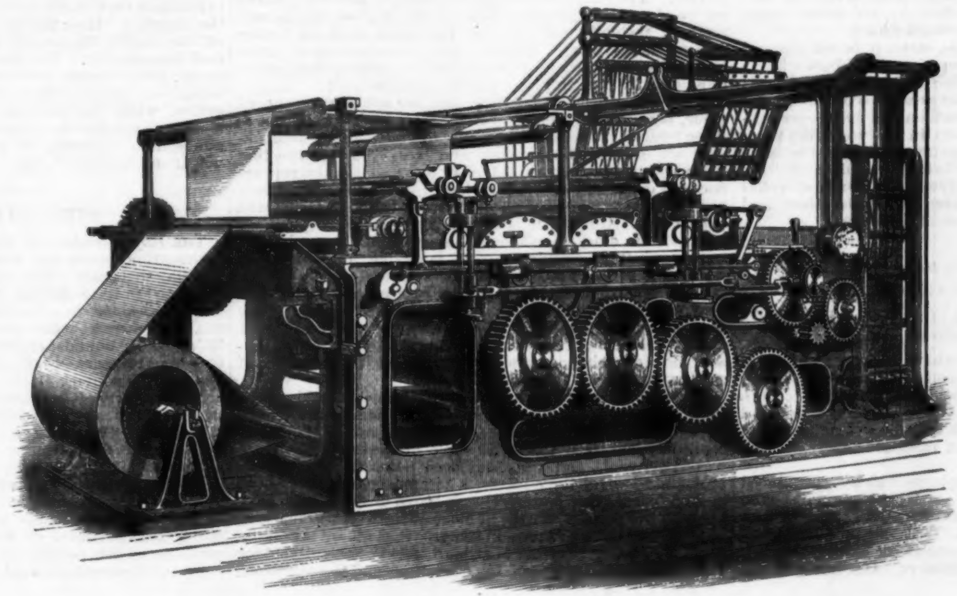
THE "VICTORY" PRINTING PRESS.

THE "Victory" printing and folding press, which we illustrate in elevation and perspective, is patented by Messrs. Duncan & Wilson, and manufactured by the "Victory" Company, of Liverpool, England.

The great advantage of this press is that, in addition to printing the paper, it turns it out ready folded. In Fig. 2, from the top of cylinder A, on which four miles of paper of the required breadth are rolled, the paper passes around a small horizontal roll situated slightly below the axis of the paper feeder. Under this an inclined surface B is placed, and small jets of water falling on this surface produce a fine spray which dampens the paper as it passes around the large roll again. Passing upwards, it is dampened on the other side by a similar arrangement B. It then passes by way of these rolls to two hollow copper cylinders C C, warmed on the inside by means of steam. By these, all irregularity in the dampening is corrected, and the absorption of the water by the paper fibres is facilitated. The paper then passes to the first form cylinder 1 D, passes between this and the impression cylinder 1 E, by which operation one side of the paper is printed. From the impression cylinder 1 E, it passes between the two cylinders, 2 D and 2 E, similar to the two preceding, when the other side is printed. From here the printed paper goes to the folding cylinders, H H H H. The inking rolls are placed above the typed cylinders as shown.

On the folding cylinders, the paper is cut into separate sheets of the required dimensions, lengthways, by circular knives, and sideways by a knife, rabbeted into a cylinder, receiving then their first fold in the direction of the cylinder axis, and the second by means of the rolls I, which again fold the already once-folded sheets. The folded sheets are then lifted by means of endless bands, and in turn piled up in layers on the receiving table K. A counter on the machines notes accurately the number of printed sheets. "Victory" presses, exactly similar to the one described, is used in printing the *Christian Union* of this city. Two of these machines are combined, the paper rolls being at opposite ends, and the finished paper being piled up on tables at the center. The London *Graphic* is printed, folded, and covered by one of these presses. An arrangement is added, when desired, by which the sheets forming the separate copies of a periodical are pasted in the cover. The folding apparatus is arranged, when ordered, to suit any desired form of paper.



THE VICTORY PRINTING AND FOLDING PRESS.—FIG. 1.

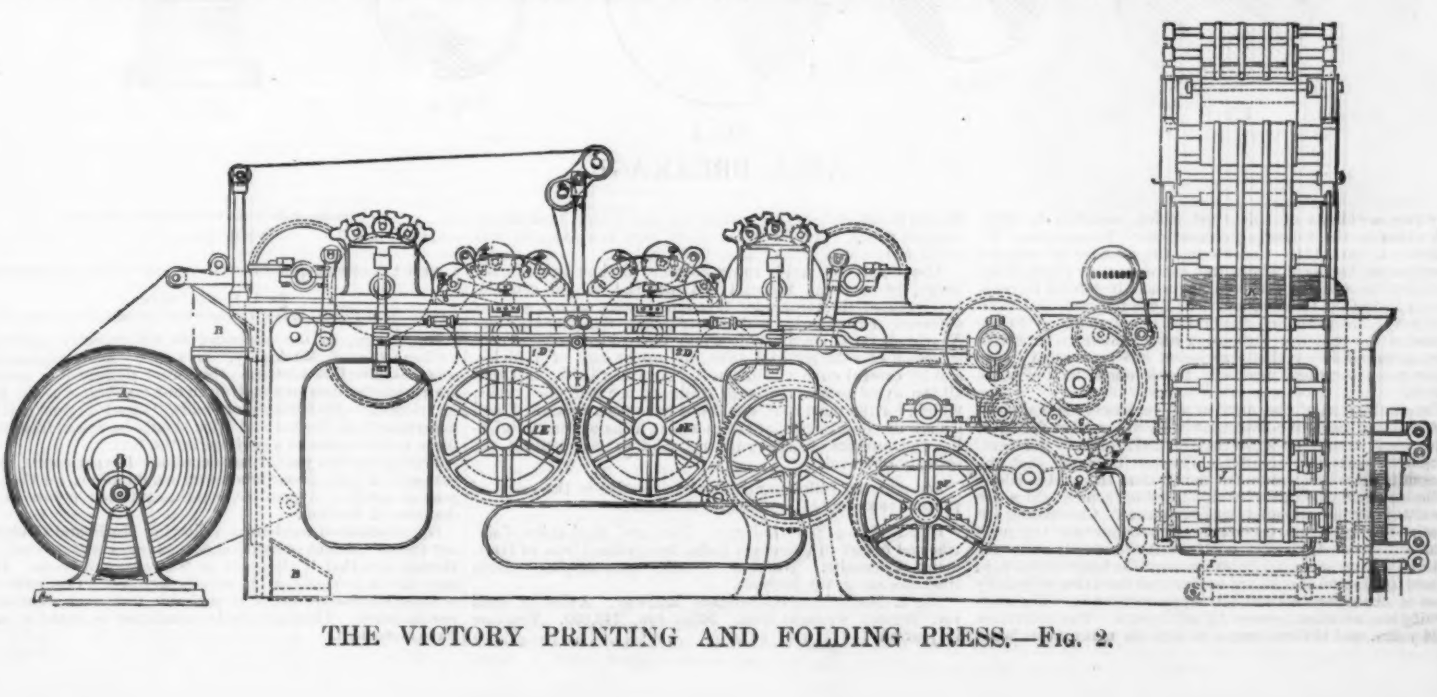
The "Victory" press will print, separate, fold, and deliver about 8,000 impressions per hour, of an eight-page newspaper, 50 inches square, or it will print, cut, fold, and paste at the back, a 24-page sheet at the rate of 7,000 per hour.

COAL REQUIRED TO PUDDLE A TON OF IRON.

IN the manufacture of iron, there has been steady progress in the direction of economy, from the time of the early workers up to the present day; but there is great room for still further reducing the cost of production. This being so, the present period of depression and small profits is an excellent time for "comparing notes" upon this important subject. There are many branches to the subject we have taken up, but at present we propose to consider only one, namely, that of the consumption of fuel. With this object in view we have ascertained, from reliable sources, the quantity of coal used in producing a ton of puddled iron at a number of the leading works in different parts of the country. We withhold the names of the works, but give their location and the date when the result was ascertained. In every case the ton is 2,240 pounds:

1. Pittsburgh, 1877: Running double turn; 2,584 pounds of coal to the ton of puddled iron; coal from Keeling mine.
2. Pittsburgh, 1877: Single turn, making six heats; 3,800 pounds of coal to 2,900 pounds of iron; equivalent to 2,935 pounds of coal to the ton of iron; hot fix and Waverly coal were used.
3. Pittsburgh, 1876: Running single turn; 2,850 pounds of coal to the ton of puddled iron.
4. Pittsburgh, 1876: Double turn; 2,736 pounds of coal to the ton of iron; a double furnace at the same mill, running double turn, produced a ton of iron with the consumption of 1,824 pounds of coal; South Side (Pittsburgh) coal.
5. Pittsburgh, 1875: Double turn; 2,736 pounds of coal to the ton of puddled iron; heating furnaces, 1,216 pounds of coal to the ton; average at this mill, for puddling, heating, scrapping, steam, etc., per ton of finished iron, 5,320 pounds of coal.
6. East St. Louis, 1874: Double turn; 2,964 pounds of coal to the ton of iron; heating, 1,419 pounds of coal; coal from Carbondale mines, on the Big Muddy, Ill.

The preceding figures are given as the best results of the respective mills, and were taken at a time when particular attention was given to the matter.



THE VICTORY PRINTING AND FOLDING PRESS.—FIG. 2.

7. Mill a hundred miles east of Pittsburgh, 1876: 2,625 pounds of coal to the ton of iron, in a single furnace, and 2,100 pounds of coal in a double furnace. The foregoing figures are taken from the books of the concern, and show the average results of a number of months of actual work. No mention was made as to whether the works were running single or double turn, but the figures unmistakably indicate double turn, and are favorable at that. It will be noticed that the double furnace shows an economy over the single, in the use of coal, of exactly 20 per cent.

8. Pittsburgh, 1876: Double turn; 2,497·36 pounds of coal to the ton of iron; ore, 448 pounds. These figures are for the month of April.

9. Chattanooga, 1876: We quote the language of our informant: "The quantity of coal used to make a ton of puddled iron and get up the furnace was 36 bushels of 80 pounds. The quantity of ore allowed for fix was 150 pounds."

10. Pittsburgh, 1876: Single turn, extending over a period of three months; 2,698 pounds of coal to the ton of iron. "This," says our informant, "includes, of course, lighting up, but does not include steam coal, which, according to our estimate, is three bushels (128 pounds) per ton of puddled bars."

11. Mill in Ohio, and on the Ohio River: From July 3, 1875, to April 15, 1876; single turn, with little exception; coal to ton of iron of 2,000 pounds, 2,660 pounds.

The foregoing figures show very distinctly what great economy there is in running double turn, as respects the consumption of coal. But in addition to this, the "wear and tear" of the furnace must be taken into consideration. This is very much less when running double turn than when running single, on account of the violent changes of temperature which occur in the latter case; but the difference in the cost of repairs under the two conditions can only be arrived at, or closely approximated, by keeping a correct account of the same for a long period of time. It will be noted also that the double furnaces consume a far less quantity of coal than single—in one clearly defined case the saving is exactly 20 per cent., which is by no means insignificant, and is worthy of serious consideration.

An English paper now before us, states it is not unusual in that country to turn out a ton of puddled bars with 21 cwt. of pig iron and 14 cwt. (1,568 lbs.) of coal. If this statement is correct, it shows a far greater economy in the use of coal in the puddling furnace than the figures presented by the American mills, as given in the preceding paragraphs, and should set our mill men to thinking. The same paper also says that at the Woolwich Arsenal careful experiments showed that considerably over 50 per cent. could be saved in fuel simply by making the grates short and wide, instead of square.—*American Manufacturer.*

[Translated from the *Moniteur Industriel Belge.*]

ON AXLE BREAKAGE.

By W. THAMM, Engineer-in-Chief of the Kaiser Ferdinand's Nordbahn Railway.

ACCORDING to numerous works which have been published regarding railway axle breakage, and the dangers resulting therefrom, ideas on this subject widely differ, and hence a few positive data based on authentic records may tend toward its elucidation. The facts have been obtained from the German and Austro-Hungarian railroads chiefly, as well as from those of other countries.

Relatively to the number of ruptures which are produced in a year, it has been determined: 1. That the number is so small that danger resulting from axles breaking may be considered as no longer existing. 2. That this number diminishes yearly. And 3. That it is greater for tenders than for locomotives, and for cars than for tenders. One hundred and sixty-two accidents of this type, which occurred in 1874, took place in the following proportions: Locomotives, 17; tenders, 34; cars, 111. Considering the number of vehicles in service on the lines where the ruptures took place, it appears that the ratio of axle breaking was 1 in 415 for locomotives, 1 in 185 for tenders, and 1 in 1,588 for cars; or 1 accident per 1,170 axles, no distinction being made as to the nature of the vehicle. Supposing each vehicle to have two axles, it would follow that a period of 585 years must elapse before an axle would probably break anew in the same vehicle.

The diminution of the number of accidents happening in 1874 is 11 per cent. in comparison with the number for 1873, 40 per cent. compared with that of 1872, and 49 per cent. compared with that of 1871. The circumstance that the axles of tenders break more frequently than the others, is due to the more considerable strains to which tender axles are submitted by the repeated use of brakes. Concerning the months during which the cases of breakage are the most abundant, those in which cold weather prevails offer the majority of instances, probably because the body of the road is then frozen, the shocks are harder, and the axles, especially those of steel, possess their minimum resistance. The average lifetime of axles is from 10 to 12 years. The maximum is 24 years, and the minimum is zero, as many axles break on first usage. It has been noted that the largest number of cases of rupture occurred while the vehicles were traveling slowly, or even while at rest.

The consequences of a broken axle are not so dangerous as commonly supposed. The results observed of the 162 cases above referred to were:

Derailments	4
Injury to vehicles	38
" " and to the road	14
Slight wounding of four men	1
No bad consequences	105
Total	162

During the preceding year the records were quite as favorable.

1873 No case of wounding.
1872..A single accident followed by personal injury.
1871..Two accidents followed by personal injury.
1870..No case of wounding.

These results are due in part to the solid construction of the vehicles, and also to the mode of coupling which sustained the car after the axle had ceased to support it.

In the above cases the rupture took place

At the journals in	56 per cent.
At the interior of the naves or stocks	22 "
In the same	13 "
Against the middle of the axle	6 "

The same proportions were observed in other years.

If axles were constructed in all their parts as they should be, according to the strains which such parts have to support, cases of rupture would be as numerous at one point as at any other, and since the plurality of breakages occurs at the journals, this shows that the latter have the weakest section. The strengthening of the journals, however, would not be of much importance, because the smallest cracks may there be instantly noticed, and the axles removed before rupture takes place. Besides, the consequences of axles broken at the journal are much less dangerous than when those of axles broken in the middle or in the nave.

It may be objected that these data are not of any especial value, because they relate only to axles broken and not to those removed from service because of cracks. But as breakages are only produced where cracks exist, it follows that there is a close relation between the two. Axle rupture does not occur suddenly when there is no fault in the metal, or in the absence of some special circumstance. The cracks appear first. Out of the 162 cases referred to, 70 per cent. began from cracks, and only 30 per cent. showed fresh fractures. This circumstance is favorable, in as much as warning is given of a damaged axle in time.

With regard to the form of the rupture, not much, in a general way, can be said. Journals almost always break concentrically from the interior toward the exterior (Figs. 1 and 2). Ruptures elsewhere, as shown in Figs. 3 to 8, present no determinate form. Fig. 9 shows the fracture of axle broken through prolonged heating.

It may be mentioned here that hard steel should not be used for axle-making, for almost all the steel axles broken were of hard steel. Moreover, among the iron axles, 29 per cent. only had fresh fractures, while in the steel axles there was 58 per cent., and cases have been noted where the latter broke into two or three pieces, a circumstance never found in iron axles. One hard steel axle broke in the middle, precisely at the point where the number of the axle was marked, the fracture falling exactly in the groove made by the figure 1. It will be seen further that hard steel is not suitable for axle-making on account of the dilatations and the numerous shocks to which axles are submitted, and which hard metals support badly. On the other hand, very few axles of soft metal were noted among those fractured.

About half the axles ruptured were broken in ordinary usage, 19 per cent. through bad material, 17 per cent. by heating, and the remainder through various causes, such as defective adjustment, bad construction, derailments, etc. Nearly all these circumstances may be avoided by good construction of vehicles and axles, by proper care of vehicles, and by careful choice of material. Add to this the fact that all the axles broken through ordinary use had old cracks, which, for the most part, could not have been remarked, and it may be considered that the means is at hand for diminishing the number of axle ruptures, and so augmenting the security of travel.

We add the following particulars relative to the cases of rupture represented, in the annexed figures:

Fig. 1. Saxon State Railway. Fore and hind axles of six-wheeled tender of passenger train, fine grained iron of Hartmann, Chemnitz. Number of miles run, 244,587. Both fractures are in the journals.

Fig 2. Magdeburg-Halberstadt Railway. Axles of mail car, fagoted wrought iron. Miles run, 243,899. Fracture in journal.

Fig. 3. Berg-Märk Railway. Open goods wagon of ten tons, Hörde patent fagoted iron. Miles run, 72,268. Fracture on exterior side of nave.

Fig. 4. South Austrian Railway. Driving axle of freight engine, having three coupled axles, refined fagoted iron. Rupture in hall crank.

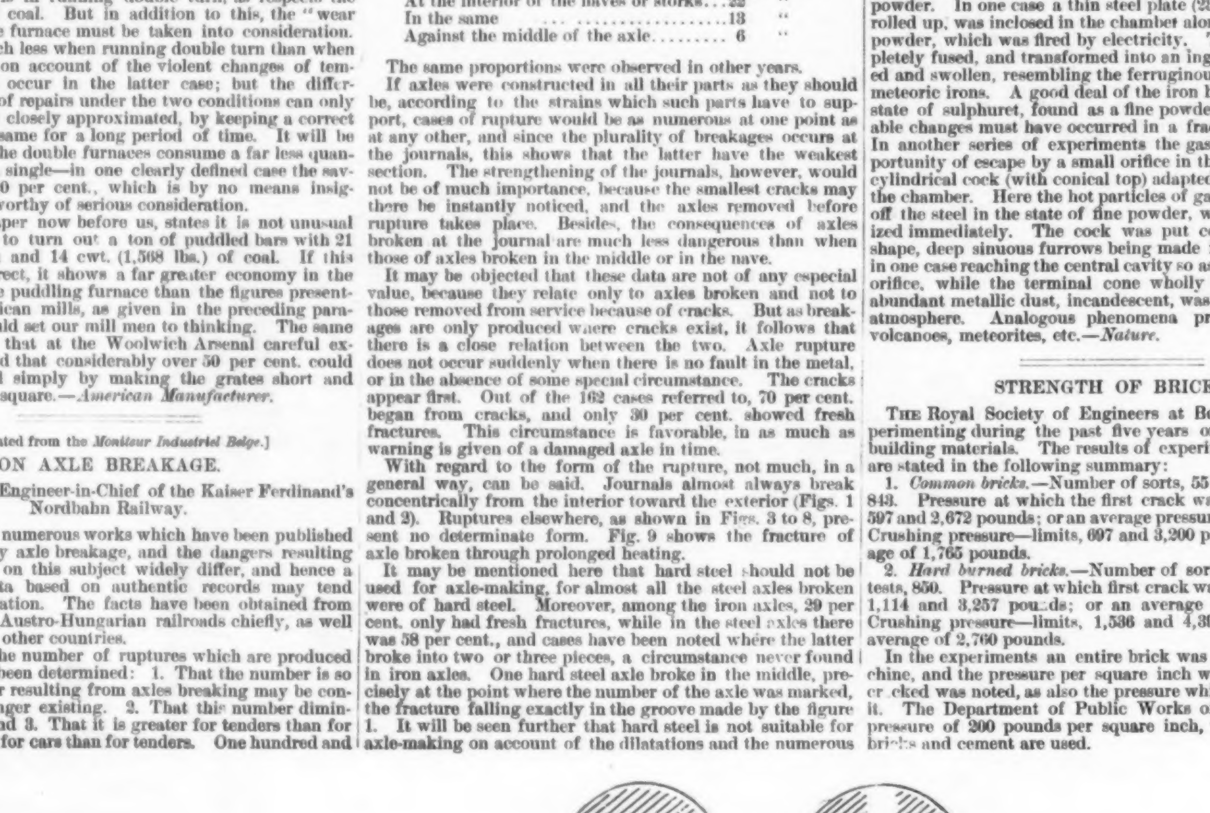
Fig. 5. Niederschles-Märk Railway. Driving axle of ordinary train engine, Krupp cast steel, not tempered. Miles run, 245,317. Break from the interior side of nave.

Fig. 6. Austrian State Railway. Six-wheeled tender of freight engine, fagoted wrought iron of Prerall. Brake in the nave of the wheel.

Fig. 7. Cologne Minden Railway. Driving axle of express engine, Bochum cast steel. Miles run, 159,990. Break from interior side of nave.

Fig. 8. South Austrian Railway. Four-wheel covered freight wagon, fagoted Zeitweg iron. Break from interior side of nave.

Fig. 9. Alsace-Lorraine Railway. Four-wheel covered freight wagon. Forged puddled steel of Vanderzypen & Charlier. Miles run, 28,059. Twisted by heating.



AXLE BREAKAGE.

ACTION OF BURNING GUNPOWDER ON STEEL.

SOME striking experiments have been lately made, by M. Daubrée, on the physical and mechanical action of strongly compressed incandescent gas arising from combustion of powder. In one case a thin steel plate (23 sq. ctm. surface), rolled up, was inclosed in the chamber along with 12 grms. of powder, which was fired by electricity. The steel was completely fused, and transformed into an ingot curiously twisted and swollen, resembling the ferruginous skeleton of some meteoric irons. A good deal of the iron had passed into the state of sulphuret, found as a fine powder. These remarkable changes must have occurred in a fraction of a second. In another series of experiments the gases formed had opportunity of escape by a small orifice in the side of a hollow cylindrical cock (with conical top) adapted and screwed into the chamber. Here the hot particles of gas fused and carried off the steel in the state of fine powder, which was sulphurized immediately. The cock was put considerably out of shape, deep sinuous furrows being made in its surface, and in one case reaching the central cavity so as to make a second orifice, while the terminal cone wholly disappeared. An abundant metallic dust, incandescent, was projected into the atmosphere. Analogous phenomena probably occur in volcanoes, meteorites, etc.—*Nature.*

STRENGTH OF BRICKS.

THE Royal Society of Engineers at Berlin has been experimenting during the past five years on the strength of building materials. The results of experiments upon bricks are stated in the following summary:

1. *Common bricks.*—Number of sorts, 55; number of tests, 843. Pressure at which the first crack was noticed—limits, 597 and 2,672 pounds; or an average pressure of 1,420 pounds. Crushing pressure—limits, 697 and 3,200 pounds; or an average of 1,765 pounds.

2. *Hard burned bricks.*—Number of sorts, 35; number of tests, 850. Pressure at which first crack was noticed—limits, 1,114 and 3,257 pounds; or an average of 2,175 pounds. Crushing pressure—limits, 1,536 and 4,395 pounds; or an average of 2,760 pounds.

In the experiments an entire brick was placed in the machine, and the pressure per square inch when the brick first cracked was noted, as also the pressure which finally crushed it. The Department of Public Works of Berlin allows a pressure of 200 pounds per square inch, where the best of bricks and cement are used.

[AMERICAN JOURNAL OF SCIENCE AND ARTS.]

FRICTION.

A NEW INVESTIGATION OF ONE OF THE LAWS OF FRICTION.

By A. S. KIMBALL,
Professor of Physics in the Worcester Institute of Industrial Science.

REULEAUX, in the appendix to his recently published "Cinematics of Machinery," says that "many engineering schemes have failed because they were designed in accordance with the statements given in our text-books as the laws of friction." He furthermore adds, "that it is time that the experiments of Bochet and Hirn should be raised from their place as foot notes to a position in the text."

During the last year, I have conducted experiments, on as extensive a scale as our laboratory would allow, for the purpose of settling, if possible, certain contested points in the doctrine of friction.

Our manuals of mechanics, following Morin and Coulomb, say the co efficient of friction *does not vary with the velocity.* Bochet says that it *decreases as the velocity increases.* Hirn says that it *increases as the velocity increases.* Contradictory as these statements are, it is probable that each contains a partial truth. They need to be combined to make a complete statement.

The results of my experiments, which this paper is to describe, would indicate that the following is the true law, within the range of my experience. The co-efficient of friction at very low velocities is small; it increases rapidly at first, then more gradually as the velocity increases, until at a certain rate, which depends upon the nature of the surfaces in contact and the intensity of the pressure, a maximum co-efficient is reached. As the velocity continues to increase beyond this point, the co-efficient decreases. An increase in the intensity of the pressure (the number of pounds on a square inch), changes the position of the maximum co-efficient, and makes it correspond to a smaller velocity. The more yielding the materials between which the friction occurs, the higher is the velocity at which the maximum co-efficient is found. Heating the rubbing bodies changes the position of the maximum co-efficient to a higher velocity, since by heat the two bodies are made softer, and are caused to yield to pressure with greater ease. For a considerable range of velocities in the vicinity of the maximum co-efficient the co efficient is sensibly constant.

The experiments upon which I base my conclusions may be classified as follows:

(1.) Sliding friction down an inclined plane.

(2.) Sliding friction at uniform velocities on a horizontal plane.

(3.) Friction of belts on the surface of cast iron pulleys.

(4.) Friction of wrought iron journals in boxes or bearings of different materials.

(1.) *Sliding friction down an inclined plane.*—A full description of the apparatus used, and some of the results obtained, will be found in *Am. Journal*, March, 1876; also in *Van Nostrand's Eclectic Engineering Journal*, June, 1876. It is sufficient for my purpose to say that the sliding body was made to carry a smoked glass, upon which was traced a waved line, which, by direct measurement, gave the time of sliding and the spaces passed over, from which it was easy to compute the corresponding co-efficients of friction. In the article referred to, no velocities less than two feet a minute were examined. An extension of the same experiment, to the case of much lower velocities, showed a curve concave toward the time line, indicating that at these velocities the co-efficient of friction was increasing. As the velocities increased, the line changed its direction, and became convex toward the time line; thus giving in the limits of one experiment a verification of the statements made above. For further particulars respecting this method of experiment, I refer to the article published in March of last year.

(2.) *Sliding friction at uniform velocities on a horizontal plane.*—A heavy pine plank, fifteen feet long, whose surface had been planed, was carefully leveled on the floor of the laboratory. The weight-box was mounted upon shoes which could be covered with the material experimented upon. To its forward end a spring dynamometer was attached, which was pulled by a cord wound around a drum, which was made to revolve at a constant velocity. The motive power was a fifteen-horse power Corliss engine, belonging to our machine shop, whose flywheel runs with great regularity at the rate of sixty revolutions a minute. A shaft from the shop runs underground to the cellar beneath my laboratory, whence, through several countershafts, the power is transmitted to any part of the room. By means of change pulleys, I can easily command a great range of velocities.

The experiments were made by drawing the box along the plane at various velocities, and reading the friction from the dynamometer. This combination answers very well for low velocities, but the slide cannot be easily stopped when the speed is great.

Several series of experiments were made, with wood on wood, also with leather on wood. The results verify the first part of my statement, that the co-efficient of friction increases with the velocity, when this is small. The following are some of the results obtained by this method of experiment:

TABLE I.—*Pine on pine. Slide loaded with 100 lbs. Velocity in inches in a minute.*

V.	Co-efficient of Friction.
5	·19
11	·20½
75	·24
300	·25

TABLE II.—*Leather on pine. Slide loaded with 100 lbs. Velocity in inches in a minute.*

V.	Co-efficient of Friction.
·79	·22
1·58	·27
3·94	·33
9·98	·36
29·14	·38
72·50	·41
157·50	·43
226·80	·45
300·	·46
466·	·47½

These experiments show the increase of friction with the velocity at low speeds quite clearly; and in connection with the series published last March, which shows its decrease at high velocities, would prove the high probability of the law as I have stated it, especially since the experiment on the inclined plane has been made to show a variation of the co-efficient from a low value, through a maximum, to a low value again, while the velocity constantly increases.

(3.) *Friction of belts on the surface of cast iron pulleys.*—A piece of leather belting was hung over a cast iron pulley. To one end a determined tension was given by a fixed weight; to the other end was attached a spring dynamometer. The tension of the ends of the belt being known, the co-efficient of friction was easily found. Several pulleys were used, and various kinds of belting; and a considerable range of tensions was employed, with uniform results.

TABLE III.

V.	T_2.	T_1.	C.
·37	30	18	·42
·52	30	12½	·44
1·1	30	11¼	·48
2·3	30	10½	·53
2·9	30	10	·55
4·4	30	9½	·58
15·4	30	6¼	·78
34·1	30	5¼	·86
80·3	30	4¾	·96
104·5	30	4½	·99
228·8	30	4¼	1·00

In the following table only velocities and relative co-efficients are given.

TABLE IV.

V.	C.
18	·82
92	·93
660	1·00
1190	·96
1980	·82
2969	·69

Two tables are here given, one selected to show the increase of the co-efficient at low speeds, the other to show the existence of a maximum co-efficient at a definite velocity. In the third table, the first column gives the velocity in feet in a minute; the second and third give the tensions of the ends of the belt; and the fourth gives the relative values of the co-efficients found, the maximum in each case being represented by 1·00. I give relative values, since they show variations more clearly than the absolute values.

(4.) *Friction of wrought iron journals in boxes of different materials.*—In this course of experiments a modification of the friction brake was used. A description of the arrangement in one series will serve for all others. A shaft 1" in diameter was adjusted so that it could be driven at almost any rate between one revolution in two days and 1,000 in a minute. A hole was bored through a block of cast iron 3½" × 3½" × 1", and carefully fitted to the shaft; rigid iron rods were screwed into the top and bottom of this block, and adjusted to stand in a vertical line at right angles to the shaft. Upon these slotted weights could be placed, and thus the pressure upon the shaft and the center of gravity of the brake could be readily adjusted. Upon the front of the block a plane mirror was fastened, and before it, at a convenient distance, were placed a scale and telescope. When the shaft was turned, the friction between it and the brake caused the latter to turn until the moment of the friction was equal to that of the brake, and the angle at which this equality was established could be read from the scale by the telescope. As the center of gravity was always adjusted so that the brake never revolved through an angle of more than three degrees, the scale readings were approximately proportional to the co-efficient of friction; and since relative and not absolute results were sought for, the labor of reduction was not undertaken. Several tables will be given to illustrate the method of conducting a series of experiments with this apparatus.

TABLE V.

Wrought iron shaft, 1" diam.; box, cast iron, 1½" long; load, 100 lbs. Shaft well oiled.

Velocity of the circumference of the shaft.

	No. 1, 72".	No. 2, 272".	No. 3, 605".	No. 4, 1320".
Scale readings.	515	500	...	...
	515	500	...	...
	515	495	...	...
	515	495	...	...
	515	495	...	...
	515	495	...	...
	515	...	485	...
	515	...	485	...
	520	...	485	...
	520	...	485	...
	520	...	485	...
	520	...	490	...
	525	...	...	480
	525	...	...	480
	525	...	...	480
	525	...	...	475
	525	...	...	480
	525	...	...	485
Mean	519	497	486	480
Position of equilibrium	464	464	464	464
Deflections	55	33	22	16

Relative values of the co-efficient of friction.

No. 1, 1·00. No. 2, ·60. No. 3, ·40. No. 4, ·29.

The results given above were made with high velocities, and show co-efficients of friction decreasing as the velocity increases.

The results of a similar series with very low speeds are given in the next table.

TABLE VI.

Velocity of the circumference of the shaft: No. 1, ·007"; No. 2, ·027"; No. 3, ·060"; No. 4, ·132" in a minute.

No. 1, ·37. No. 2, ·51. No. 3, ·73. No. 4, 1·00.

These results, unlike those of the former table, show a co-efficient of friction increasing as the velocity increases.

A large number of experiments similar to those given above have been made with uniform results.

I have been able to verify experimentally the law stated early in this paper in the following cases: Wood sliding on wood, wood on iron, leather on iron, zinc on iron, and copper on iron; and to obtain results verifying the first half of the law in the case of leather on wood.

The experiments above detailed make it easy to explain the various results obtained by the three authorities quoted at the beginning of this paper. Morin experimented under conditions which gave him a co-efficient very near the maximum, and thus his results are approximately constant. Bochet experimented with railway trains, his conditions were high speeds, hard rubbing surfaces, and great intensity of pressure. All these circumstances are favorable to the result be obtained, namely, a co-efficient decreasing as the velocity increases. Hirn, on the other hand, employed very light pressures, less than two pounds on a square inch, and kept his rubbing surfaces so thoroughly lubricated that the friction was between oil and oil instead of two metal surfaces; his speeds were not very great. These conditions are precisely the ones I have found favorable to the results be reached—a co-efficient, increasing as the velocity increases. It would be very easy to form a theory which would account for the variation of friction with the velocity, under the rule I have given.

It is well known that if a given deflection in a bar is produced by a weight acting for five seconds, for example, that the same deflection may be produced, by a less weight, acting for a longer time. Now, as the force required to overcome friction is, partially at least, expended in bending down the minute irregularities on the surface of the rubbing bodies, it becomes evident how, other things being equal, a rapid motion would call for the exertion of a greater force than would be required if the motion were slow.

On the other hand, the longer two surfaces under pressure are in contact the greater must be the interlocking of the irregularities upon the rubbing surfaces. On this account a rapid motion would not require the expenditure of so great a force to overcome the friction. Thus, we have two effects, varying with the velocity, but having opposite signs. Now it is not probable, from the nature of the case, that these effects are numerically equal, or even proportional, and thus we can, at the least, say that the conditions are favorable to the existence of a maximum resultant effect. Having, however, ascertained the fact by experiment, the explanation becomes a matter of minor importance.

It may be said that these facts have no practical importance at the velocities ordinarily employed. I would call attention to Table V, where it will be seen that by increasing the velocity of shafting within the limits of ordinary shop practice, a reduction of the co-efficient of friction of quite fifty per cent. may be made. The pressure on the shaft might also be reduced, for it would be unnecessary to maintain so great a tension upon the belts, and thus in some cases a very considerable economy of power might be effected. We know that in many shops a large fraction of the power developed by the engine is expended in overcoming the friction of the shafting and machinery.

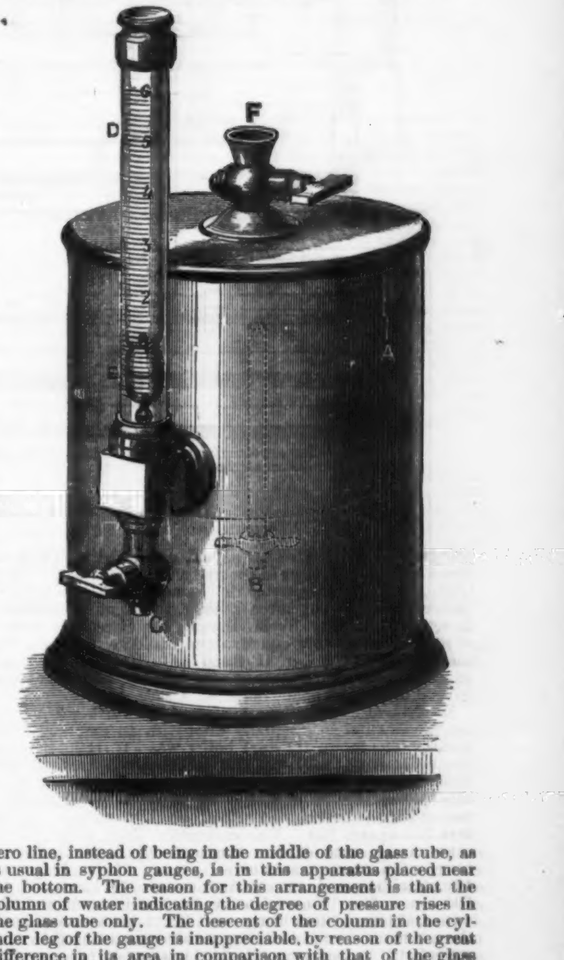
On the other hand, it is desirable that the friction of the belt upon the pulley should be as great as possible. The conditions usually met with, which determine the friction of belts, are, low intensities of pressure, a rubbing surface which yields with considerable ease. In such cases a high speed is needed to develop the greatest amount of friction. See Tables III and IV.

I am under obligations to Messrs. Butterfield and Wilson, who have rendered me valuable assistance in conducting the experimental work of this investigation.

I hope soon to be able to give tabulated results, which may have a certain practical value to working engineers.

GAS PRESSURE-GAUGE.

THIS pressure-gauge is constructed as follows: A cylinder A, of pure tin, 7 inches in diameter, closed at the top and bottom by plates of the same metal, forms one leg of a syphon pressure-gauge. A glass tube D, half an inch internal diameter, flashed at the back with white glass, and graduated on the front in linear inches, is cemented into a metal screw connection. It is then put in communication with the cylinder by means of an elbow fixed in the side of the latter, near the bottom. Into this the glass tube is screwed, and forms the other leg of the gauge. A cock F, is fixed into the top of the cylinder, for the purpose of permitting the entry of the atmospheric pressure when it is desired to examine the water line. Another cock C, is fixed into the bottom of the elbow, beneath the glass tube, for the purpose of letting out any superfluous water from the gauge. The



zero line, instead of being in the middle of the glass tube, as is usual in syphon gauges, is in this apparatus placed near the bottom. The reason for this arrangement is that the column of water indicating the degree of pressure rises in the glass tube only. The descent of the column in the cylinder leg of the gauge is inappreciable, by reason of the great difference in its area in comparison with that of the glass tube. Communication with the gas is in this case made through the bottom of the cylinder, by means of a tube B, rising above the surface of the water, or it may be made by a connection fixed on the side of the cylinder near the top.

The action of this gauge is as follows: Sufficient water having been first put into the cylinder through the cock at the top to bring the column of water in the tube up to the zero line, the cock is closed. Gas being admitted into the cylinder displaces the water, and drives it up into the glass tube, until the pressure of that column balances the pressure in the cylinder. The pressure in inches of water is then easily read off on the graduated tube. It is not necessary, even if it were possible, to verify the position of the column of water in both legs of the pressure-gauge, and those who have much to do with syphon gauges will at once appreciate the advantage of having to deal with only one surface of water.—*Jour. of Gas Lighting.*

[ENGINEERING.]

STEAM BOILER ECONOMY.

For many years the Société Industrielle de Mulhouse has taken a most active part in promoting the economical production and use of steam power, and the experiments and researches carried out under the auspices of the association have furnished a great amount of valuable information regarding engine and boiler performances. Amongst the questions which the Société has more or less thoroughly investigated are the relative merits of internally and externally fired boilers, and the conclusions arrived at are, we think, of sufficient interest to warrant our placing them fully before our readers:

In England, as is well known, the general preference is for boilers internally fired, such, for instance, as the Cornish or Lancashire types; while on the Continent, on the other hand, externally fired boilers, and especially those of the "elephant" class or *chaudières à bouilleurs*, are most extensively used. To some extent, this difference of practice is due to the different character of the fuel used, the inferior coals employed in many parts of Belgium, France, and Germany requiring larger firegrates than can be conveniently provided in boilers of the Cornish or Lancashire types; but apart from this the externally fired boilers are in much favor on the Continent from their moderate first cost and alleged cheapness of maintenance.

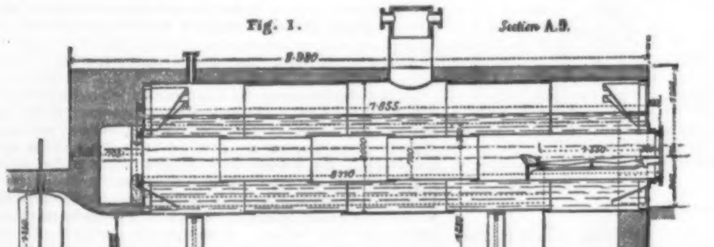
In Alsace the "elephant" boiler has long been, and still is, a favorite type, and its merits, as compared with other types, have on several occasions been the subject of investigations by the Société Industrielle de Mulhouse. Indeed, as long ago as 1859, the society offered a prize for a boiler capable of evaporating 7½ lbs. of water per pound of Ronchamp coal of average quality, and three boilers—all of the laid before them the particulars of some experiments made by MM. Meunier and Hallauer on two internally fired boilers—one of the Cornish and one of the Lancashire type—made by Messrs. Sulzer Brothers, and two externally fired Wesserling boilers, these experiments showing an advantage of 8·8 per cent. in favor of the boilers internally fired. Subsequently, however, the results of these trials were challenged by the engineers of the Société Alsacienne de Constructions Mécaniques on the score that the experiments had lasted but two days, that the boilers were not fired by the same stoker, and that evidence was wanting as to the boilers being in a similar state as to the condition of their internal and external surfaces, etc. It was also urged—and justly—that the comparative evaporative power of a boiler per pound of fuel burnt was not the sole test by which it was to be judged, but that its security and cost of maintenance should also be considered. In view of these objections to previous experiments, the committee of the mechanical section of the Société Industrielle de Mulhouse desired to settle once for all the question as to the relative merits of the two types of boilers, and eventually a correspondence was entered into with the Société Alsacienne de Constructions Mécaniques, which resulted in that firm undertaking, the erection of two boilers on which experiments could be made, the Société Industrielle de Mulhouse on their parts appointing a special committee, consisting of MM. Ernest Zuber, Gustav Dollfus, Ch. Meunier-Dollfus, O. Hallauer, Alf. Bœringer, Pouparain, Ed. Gærig, Wacker, and Th. Schlumberger, to carry out these trials. It is to the report of this committee that we are indebted for the facts which we are placing before our readers.

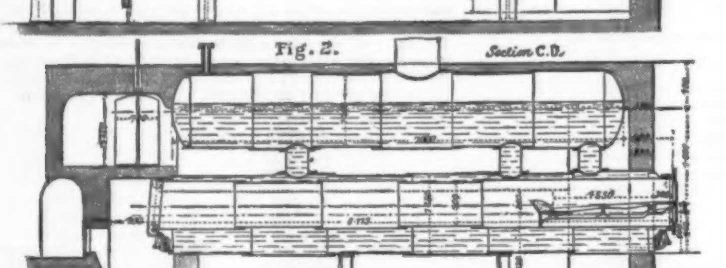
The two types of boilers selected for comparison were respectively a Lancashire boiler and an elephant boiler with two "bouilleurs," and it was arranged that these boilers the flue plates 0·51 in. The combined width of the firegrates is 4 ft. 6¾ in. and their length 5 ft. 1 in., this length, including 6·7 in formed by the parts of the bars resting on iron supports. Taking the effective length of the grates, therefore, at 4 ft. 6·3 in., we get a firegrate area of 20·5 square feet. The thickness of the bars is 0·59 in. and the width of the spaces between them 0·236 in., the air spaces thus amounting to two sevenths of the grate area, or 5·85 square feet. The total heating surface of the boiler is 612·5 square feet, divided as follows:

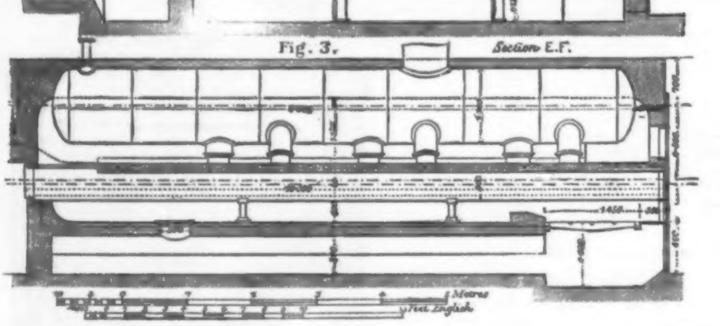
	Sq. ft.
Surface of outer shell exposed in side and bottom flues	271·03
Surface of internal flues, deducting parts below grates	333·25
Surface at back end of boiler	8·22
Total	612·50

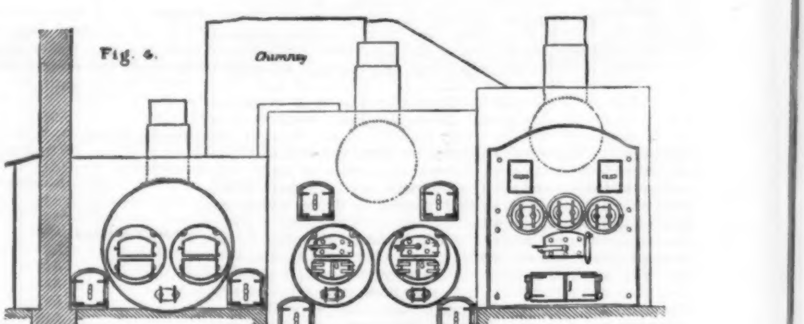
The construction of the bridge and the general details of the setting will be readily understood from the views given herewith, and it will be seen from these that the products of combustion after leaving the internal flues are let into the side flues and return to the front of the boiler, finally passing along the bottom flue to the chimney. The setting thus differs from that now regarded here as the best practice, and according to which the gases from the internal flues are led first along the bottom of the boiler and then back along the sides to the chimney. This last mode of setting undoubtedly contributes to the durability of the boiler, but it is doubtful if either mode gives any perceptible advantage over the other as far as evaporative efficiency is concerned.

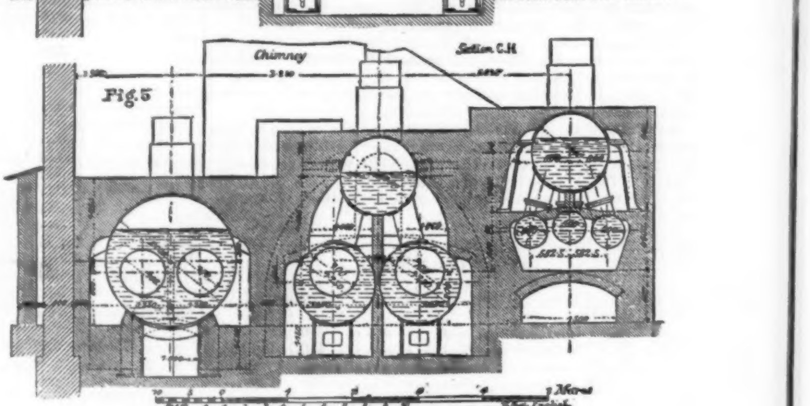
The Fairbairn Boiler.—The "Fairbairn" boiler, as de-











STEAM BOILERS OF THE SOCIETE INDUSTRIELLE DE MULHOUSE

tubular type—were then tested and compared with a *chaudière à bouilleurs* such as is generally used in Alsace. These trials showed at first a superior comparative power in the tubular boilers, but after a long series of experiments directed principally by M. Burnat, the committee arrived at the conclusion that equal results could be obtained with the "elephant" boiler if fitted with feed water heaters or as they are named *réchauffeurs*. These trials thus tended to establish the elephant boiler in Alsace.

In 1863, again, M. Burnat carried out further trials, and again compared an internally fired with an externally fired boiler. The internally fired boiler was 7 ft. 1½ in. in diameter by 29 ft. 3¾ in. long, and it contained two furnaces opening into an oval combustion chamber from which seven large tubes 11·8 in. and 14·17 in. in diameter extended to the end of the boiler. The total heating surface exposed was 775 square feet. The externally fired boiler, on the other hand, was of the elephant type, 39 ft. 6½ in. long, with three "bouilleurs" 32 ft. 9½ in. long, and 16¼ in. in diameter. The surface exposed by this boiler was 506 square feet. The trials of these boilers showed that with 3,458 lbs. of Ronchamp coal burnt in twelve hours in the internally fired boiler—the combustion being thus at the rate of 0·37 lb. per square foot of heating surface per hour—8·78 lbs. of water were evaporated per pound of coal, the latter yielding 10 per cent. of ashes and clinkers. In the case of the externally fired boiler, on the other hand, 4,066 lbs. of coal were burnt in twelve hours, the combustion being thus at the rate of 0·669 lb. of coal per square foot of heating surface per hour, and the evaporation was 7·43 lbs. of water per pound of coal. Judged merely by the evaporation per pound of fuel burnt, the externally fired boiler gave a result inferior to that internally fired in the proportion of 7·43 to 8·78, or 90·8 to 100; but it is to be borne in mind that the externally fired boiler was much more hardly worked than the other, and the evaporation per pound of fuel cannot therefore be alone taken as a measure of its efficiency. On this point we shall have more to say hereafter when comparing the above results with those derived from other boilers.

In 1872, too, the Société Industrielle de Mulhouse had should have the same heating and grate surface, that they should be fired by the same stoker, and that they should burn the same quality and quantity of coal and with the same draught. To these two boilers the Société Alsacienne de Constructions Mécaniques added a third of the Fairbairn type, but somewhat modified in its construction. This boiler had the same grate surface as the others, but a larger heating surface, it being impossible to reduce the latter to that of the other boilers without disproportionately reducing the length of the Fairbairn boiler. The three boilers were completed and first fired in August, 1874, and the experiments with them were commenced at the end of the month following.

In making the trials, it was determined that they should last sufficiently long to get rid of the effect of irregularities in working, while besides taking account of the consumption of coal and water, arrangements were made for determining the temperature of the products of combustion at their entrance to the chimney, and for ascertaining the percentage of water carried off with the steam. Before speaking of the results obtained, however, we must describe the boilers themselves, referring for that purpose to our engravings on the present and opposite pages.

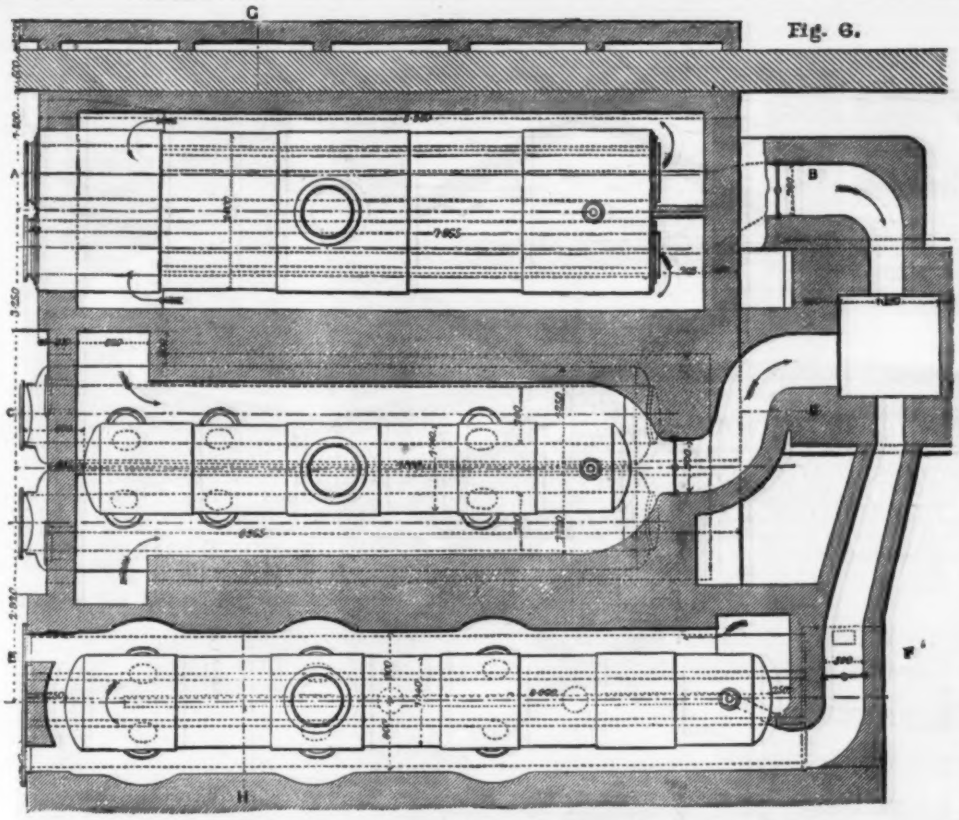
As will be seen from Figs. 4 and 5, and the plan Fig. 6, the three experimental boilers are mounted side by side, the Fairbairn boiler being between the other two. A chimney situated in the rear is common to the three boilers, and none of the latter are fitted with feed-water heaters. By the side of the experimental "elephant" boilers is situated a smaller one working into an independent chimney, while the setting of the Lancashire boiler, on the other hand, touches the outer wall of the boiler house. To avoid any cooling from this cause, however, a supplementary wall was erected outside that of the building, an air space being left between the two stalls, as shown in the section Fig. 5, and plan Fig. 6. By this air space any external radiation is practically avoided.

The Lancashire Boiler.—The Lancashire boiler has an outer shell 6 ft. 6¾ in. in diameter by 25 ft. 9 in. long, and it contains two flues 2 ft. 3·6 in. in diameter. The shell plates are 0·63 in. thick, the end plates 0·748 in. thick, and signed by the late Sir William Fairbairn, consists of three cylindrical shells, two of these—each traversed concentrically by an internal flue—being placed side by side at a short distance apart, while the third is placed above and between them, being joined to them by suitable connecting tubes. The "Fairbairn" boiler, erected by the Société Alsacienne de Constructions Mécaniques, is, however, as shown by our engravings, of a somewhat modified design, the two flues in the lower shells being placed eccentrically as shown. These two lower shells are each 4 ft. 1·2 in. in diameter by 25 ft. 9 in. long, and the flues they contain are 2 ft. 3·6 in. in diameter. The lower cylinders are each connected by three tubes or mouthpieces with the upper cylinder which is 3 ft. 8·9 in. in diameter by 22 ft. 1½ in. long. The upper cylinder is made of plates ½ in., and the two lower of plates 0·53 in. thick, while the internal flues are made of 0·51 in. and the ends of 0·71 in. plates. The grates, which are contained in the internal flues of the lower cylinder, are precisely identical with those of the Lancashire boiler. The heating surface is 1017·48 square feet, divided as follows:

	Sq. ft.
Surface exposed by the upper cylinder	144·88
Surface exposed by the two lower cylinders to the second "run" of the gases	314·49
Surface exposed by the two lower cylinders to the third "run" of the gases	182·96
Surface exposed by six connecting tubes	38·04
Surface exposed by two internal flues deducting surface below grates	333·27
Surface exposed at front of upper cylinder	3·84
Total	1017·48

It will be seen on reference to our engravings of this boiler on pages 4 and 5, that the setting is so arranged that on leaving the internal flues of the lower shells the gases return to the front end along the sides and bottoms of the two lower cylinders, and thence pass the chimney between these cylinders and the third one above, a mid-feather wall dividing the flues so that the products of combustion

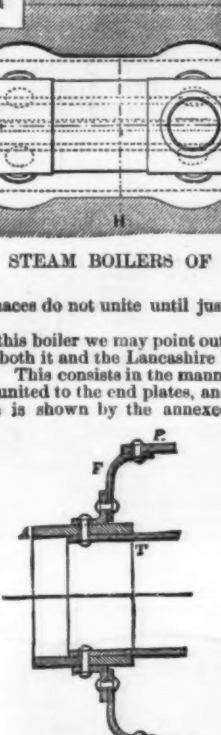
Fig. 6.



STEAM BOILERS OF THE SOCIETE INDUSTRIELLE DE MULHOUSE.

from the two furnaces do not unite until just before entering the chimney.

Before leaving this boiler we may point out a constructive detail adopted in both it and the Lancashire boiler which is worthy of notice. This consists in the manner in which the internal flues are united to the end plates, and a sketch of it to a larger scale is shown by the annexed figure. The



arrangement consists in surrounding the end of the flue T with a stout wrought iron ring A, which is in its turn encircled by the angle iron ring F riveted to it and to the boiler end. The ring A is turned slightly conical, and when it is desired to draw out the flue, the rivets which connect it to the angle iron ring F are cut, and the ring A withdrawn, leaving the flue free.

The setting of this boiler is arranged, as shown in our engravings, so that the products of combustion act first on the surfaces of the three "bouilleurs," then return to the front end along one side of the main cylinder, and finally pass to the chimney along the other side.

As we have already stated, the three boilers work in connection with one chimney, the flue of the Lancashire boiler entering this chimney at a lower point than the others. The report on the experiments states that with the damper open the draught was equally good in all the boilers. As will be seen from our engravings, each of the boilers was provided with a "butterfly" damper, these dampers being worked by levers provided with sectors. The areas of opening of the dampers corresponding to each notch of the sectors were measured and were found to be as follows:

Number of Notch........	1	2	3	4	5	6	7
Area in square feet for elephant boiler.......	0·325	0·394	0·533	0·812	1·161	1·509	1·885
Area in square feet for Lancashire and Fairbairn boiler..........	0·28	0·487	0·694	1·005	1·028	2·146	

During the experiments the amounts of opening of the dampers were carefully recorded, as we shall explain hereafter. For convenience of reference and comparison, we annex in Table No. I. a summary of the dimensions, etc., of the three boilers we have been describing.

It will be observed in examining the above data that the two boilers which it was especially desired to compare—namely, the Lancashire and Elephant boilers—are of such dimensions as to render it possible to work them under precisely similar conditions. the heating and firegrate surfaces and the volumes occupied by the water being practically identical in the two boilers. In the Fairbairn boiler the firegrate area is the same as in the others, but the heating

TABLE No. I.—GIVING THE PRINCIPAL DIMENSIONS OF THE EXPERIMENTAL BOILERS.

DATA.	Fairbairn Boiler.	Lancashire Boiler.	Elephant Boiler.
Length....................	25 ft. 9 in. & 22ft. 11⅝ in.	25 ft. 9 in.	29 ft. 6¾ in. & 32 ft. 9¾ in.
Total heating surface........	1017·48 sq. ft.	612·5 sq. ft.	607·6 sq. ft.
Grate area..................	20·5 sq. ft.	20·5 "	20·05 "
Square feet of heating surface per square foot of grate..................	49·53	29·82	30·29
Total capacity	642·73 cub. ft.	638·31 cub. ft.	531·2 cub. ft.
Volume occupied by water..........	544·87 "	413·21 "	408·16 "
" " steam..........	97·86 "	225·1 "	123·04 "
Square feet of heating surface per cubic foot of water capacity..........	1.86 sq. ft.	1.48 sq. ft.	1·49 sq. ft.
Weight of boiler with accessories	43·120 lbs.	36·520 lbs.	31·900 lbs.
" " per square foot of heating surface	423 lbs.	595 lbs.	525 lbs.
Cost of boiler..................	656·8*l*.	563·44*l*.	442·4*l*.
Cost of setting..................	120*l*.	112*l*.	120*l*.
Total cost..................	776·8*l*.	675·44*l*.	562·4*l*.

The "Elephant" Boiler, or Chaudière à Bouilleurs.—The main body of this boiler is 2 ft. 6¾ in. long by 3 ft. 8·9 in. in diameter, and is made of ½ in. plates, except the ends, which are 0·55 in thick. The three lower cylinders or *bouilleurs* are 19·7 in in diameter by 32 ft. 9¾ in. long. and are made of 0·39 in. plates, while each communicates with the main body of the boiler by three connecting tubes. The grate is 4 ft. 9·1 in. wide by 4 ft. 9·3 in. long over all, this including 6·7 in. taken up by the bearings of the bars. Taking the effective length of the grate as 4 ft. 2·6 in., the area is 20·05 square feet, or nearly half a square foot less than the grate areas of the Lancashire and Fairbairn boilers. The heating surface is 607·6 square feet, divided as follows:

	Sq. ft.
Surface exposed by main body of boiler ..	199·48
" " three lower cyilnders..	385·68
" " nine connecting pipes..	22·44
Total	607·60

surface is, from the construction of the boiler, considerably larger, while its water capacity per square foot of heating surface is also larger. It is, however, of proportions which render a comparison of its performances with those of the other steam generators very interesting. We have now fully described these three experimental boilers, and we shall, in our next article, give an account of the manner in which the trials made with them were carried out.

THE ABERDEEN COMB INDUSTRY.—An industry peculiar to the "granite town" is the manufacture of combs, which affords employment to about 2,000 persons. The trade is unfortunately at present in a bad way, and it appears it is also suffering from a scarcity of the chief raw material—horns. From 80,000 to 100,000 are used up weekly in the Aberdeen comb factories, and we find the present dearth ascribed to the prohibition of the importation of cattle. But this must be a mistake, as it is the custom to ship horns by themselves from South America and other sources of supply.

HEATING FEED-WATER.

By J. HAUG, M.E.

AS SOME doubts seem to exist among steam users about the advantages of heating the feed-water, it might be appropriate to give a few figures about the economy to be obtained thereby.

To heat a pound of water from zero to the boiling point, and convert it into steam at a certain pressure, a certain amount of heat has to be imparted to it. A "unit of heat" is the amount necessary to raise *one* pound of water *one* degree in temperature. Then

At 15 lbs.	above atmosphere	1191 units	are necessary.
" 30	"	1198	"
" 45	"	1203	"
" 60	"	1208	"
" 75	"	1212	"
" 90	"	1214	"

Taking 1,200 as an average, and assuming the average natural temperature of water at about 50°, we have to impart 1150 units of heat to every pound of water to convert it into steam. A feed-water heater will thus, for every 100° the feed water is raised in temperature, effect a saving of $\frac{100 \times 100}{1150} = 8·7$ per cent.; the greatest economy would be attained if the feed could be heated to the boiling point. Taking the latter at 212°, the gain would then be $\frac{(212 - 50) \times 100}{1150} = 14$ per cent.

In condensing engines the feed-water is taken from the hot well, which generally is kept at 120° to 130°, as a higher temperature would impair the vacuum, and thus neutralize what is gained by a higher temperature of feed.

In some marine engines the feed-water has been heated to a higher degree by taking it from the hot well into the top of the condenser, or around and through the exhaust pipe, to expose it to the steam coming out of the cylinder, before it is condensed. Considerable gain has been claimed by inventors of these plans, but as they have not been adopted to any extent, it may be doubted whether their advantage is universally acknowledged.

For stationary condensing engines the so-called economizers have found extensive application; they consist of coils or rows of tubes, located in the back flue of the boiler; the feed-water is *forced* through them, and can thus be heated to very near the boiling point. Some of these were shown in the British section, in the southeast corner of Machinery Hall, in the Centennial Exhibition, and very elaborate and costly structures they were. Their vertical tubes had a slow-moving set of scraping rings around them, to keep them free from any soot that might impair their conductive power. Taking the temperature of the hot well at 120°, and assuming that the feed is heated to 200°, the gain would be

$$\frac{(200 - 120) \times 100}{1200 - 120} = 7·4 \text{ per cent.}$$

For *non-condensing* engines, where the feed would have to be raised from 50°, the gain would be

$$\frac{(200 - 50)\,100}{1200 - 50} = 13 \text{ per cent.}$$

For non-condensing engines the simplest way to heat the feed is by the exhaust from the cylinder, either passing it into the feed-water tank (which is done in locomotives sometimes), or by *forcing* the feed-water through a coil of pipes surrounded by the exhaust steam. Or the feed, in its way to the boiler, is forced through a cylindrical vessel, and the exhaust steam conducted through it in small tubes, after the manner of a surface condenser. If these arrangements are provided with sufficient heating surface, the feed may be heated to 180° or 200°, but care should be taken to provide ample and unobstructed passage to the exhaust, so as not to increase the back pressure, for if the latter is only one pound per square inch higher, the loss, especially where the steam is greatly expanded, may come very near the gain by feed-heating. In a Corliss engine, working with 60 lbs. pressure, cutting off at 1-10th, the mean pressure is about 14½ lbs. per square inch; if the back presure is raised one pound, the mean pressure would only be 13½, showing a loss of $\left(\frac{1 \times 100}{14·5}\right) = 7$ per cent.

The cost of heating the feed is represented by the interest on the first cost of the heater and its cost of maintenance, and will vary somewhat according to construction, etc. On an average the *net gain* by heating the feed may be assumed as about five per cent. for condensing, and ten per cent. for non-condensing engines.—*Polytechnic Review.*

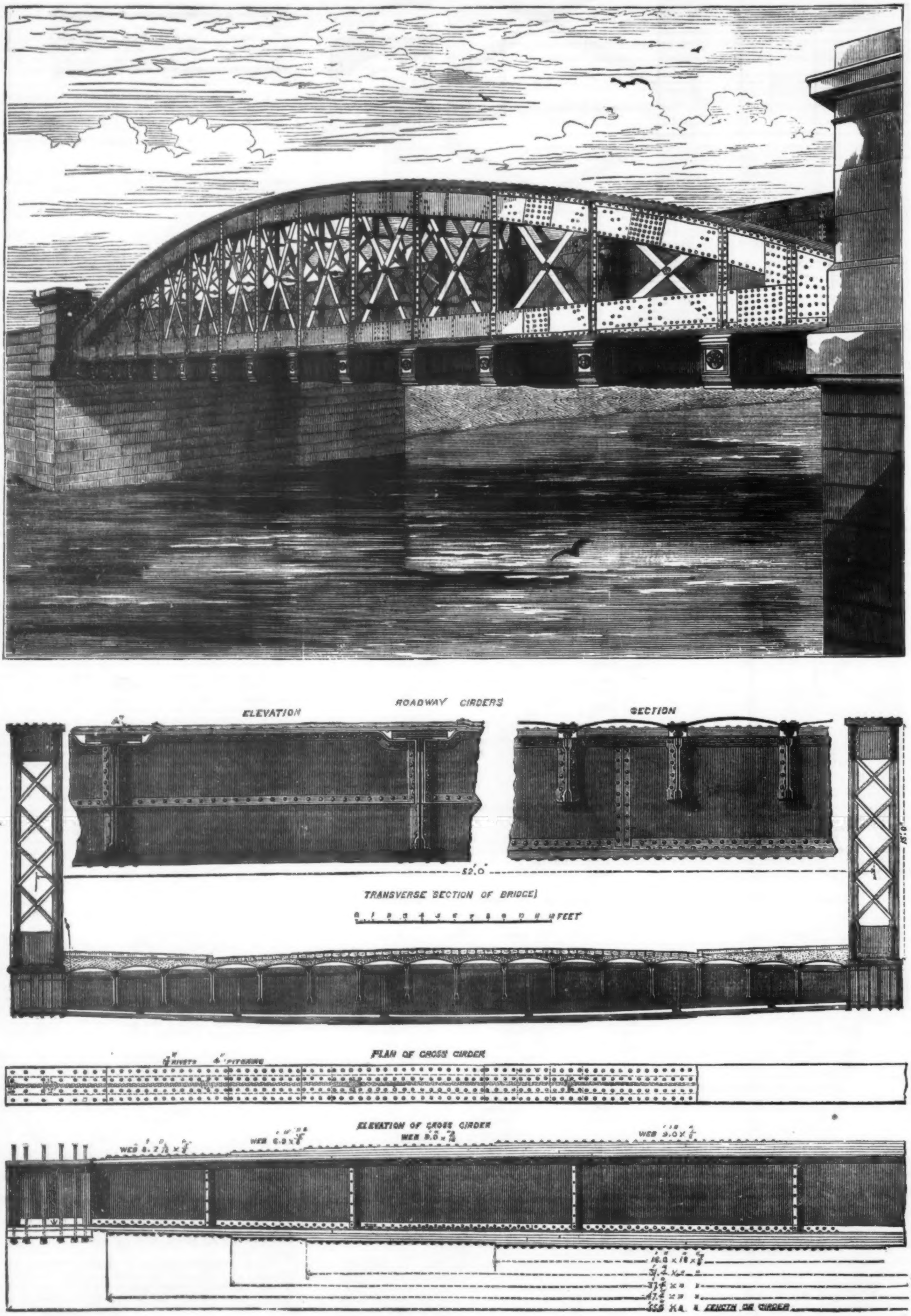
THE LONDON "TIMES" ON AMERICAN MANUFACTURES.

"IT is incumbent upon the manufacturers of the United Kingdom to show the world at Paris next year that they have not fallen behind the position they once occupied. The competition at Philadelphia was not altogether satisfactory to us.

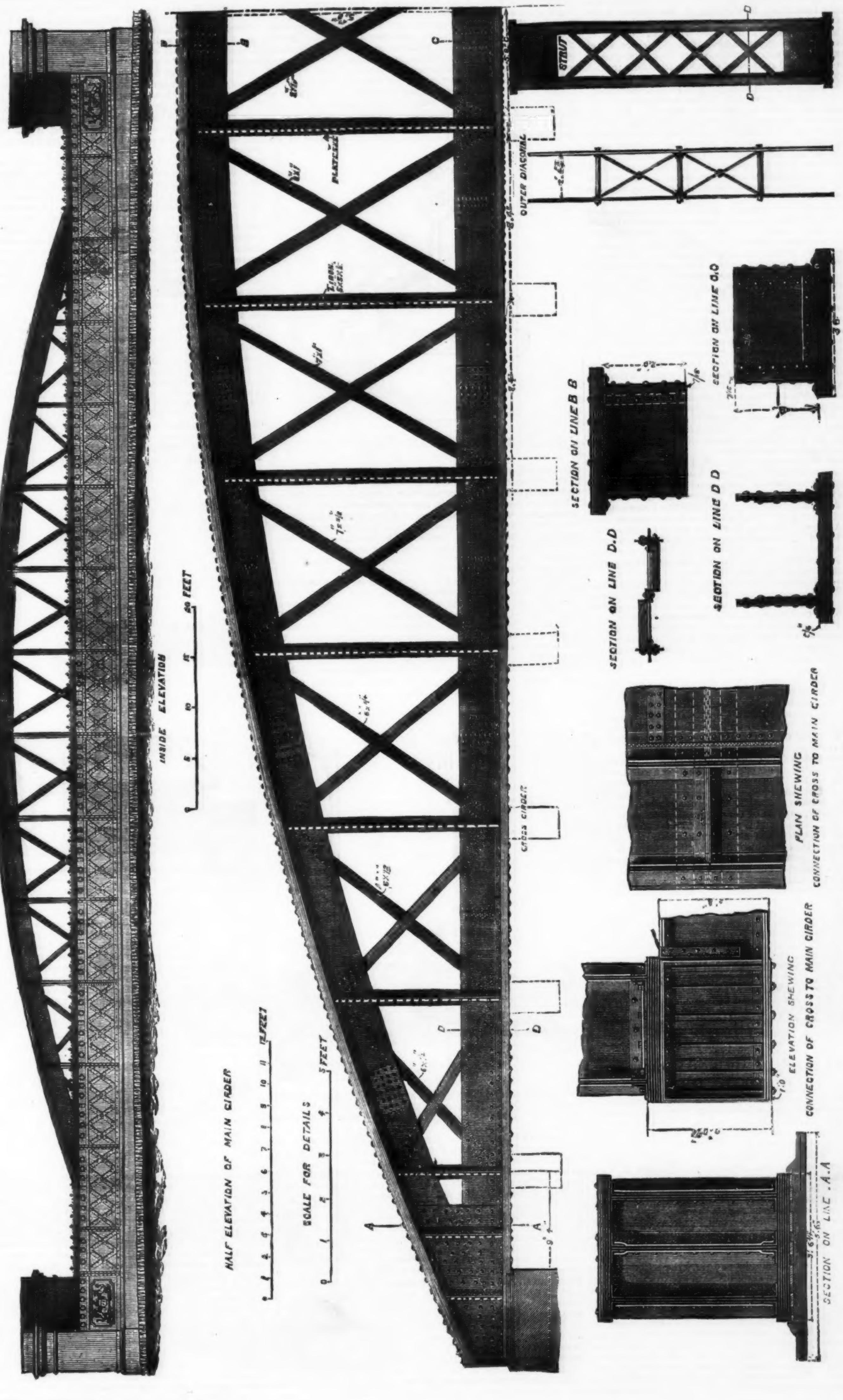
"It is true that every nation has an advantage in exhibitions held within its own area; but the products of the industry of the United States surpassed our own oftener than can be explained by this circumstance. It appeared as if there was a greater economy of labor habitually practised in the States, and in conjunction with this there was evidence of the more constant presence of a presiding mind superintending every process of industry. The best machine in the world will fail to give satisfaction if there is not an intelligent human being at hand to watch it, to take care of it, to detect the smallest failure in its working as soon as it is developed, and to suggest and supply the means of correcting any miscarriage of its functions.

"A steam engine dropped from heaven in the middle of Africa might be adored, but could not be put to any use. The failure of many of our industrial enterprises in foreign parts can be traced to the difficulty in procuring agents and assistants that can be taught to use the machines committed to their care.

"Much of the mechanical work shown at Philadelphia was executed with a fineness that could not have been exceeded if every man who had any share in its production had originally conceived it, and had been solely interested in its success. There was evidence of personal care and personal anxiety; every stage must have been watched with intelligence and with zeal. In comparing the results with our own, we are painfully suspicious that they revealed the application of more brains than we always have at our command."



IRWELL STREET BRIDGE, MANCHESTER, ENG. J. G. LYNDE, M.I.C.E., ENGINEER.



IRWELL STREET BRIDGE, MANCHESTER. J. G. LYNDE, M.I.C.E, ENGINEER.

IRWELL RIVER BRIDGE, MANCHESTER, ENG.

AMONGST the various and important improvements that have recently been made in the city of Manchester is the erection of another bridge over the river Irwell, thereby increasing the means of communication with Salford, and relieving New Bailey street, Albert Bridge, Bridge street, John Dalton street, and Princess street from the greater part of the heavy coal traffic and merchandise from the adjacent goods stations of the Lancashire and Yorkshire Railway. From the position of the bridge, and the requirements of the parties interested in the navigation, to preserve a sufficient headway, and the necessity for easy gradients for the approaches, it was requisite, in order to comply with the severe conditions respecting the thickness of the roadway platform, to display more than ordinary ingenuity in preparing the designs, so as not to impair the strength of the structure in any part. The bridge is slightly on the skew, one of the main girders being 130 ft. and the other 127 ft. in length; the width of the roadway between the parapets is 48 ft.

Owing to the heavy traffic the girders are of more than the usual strength, and extra allowance is also made for the corrosion of the wrought iron, due to the exceptional atmospheric impurities which rise from the river. The main girders are on the bow-string principle, with double triangular lattice and verticular bars. They are 15 ft. deep in the centre, the arch being a true parabola. The top and bottom booms are trough-shaped, the top being composed of seven flange plates $\frac{7}{16}$ in. thick, and the bottom of six plates of the same thickness, 3 ft. 6 in. in width, attached by four angle irons, 4 in. by 4 in. by $\frac{5}{8}$ in., to two rows of web plates consisting of two plates 2 ft. deep by $\frac{5}{8}$ in. thick, increasing in thickness towards the ends. Gusset plates are attached at intervals inside the two webs; and to these webs are riveted the diagonal and vertical bars. The rivets are $\frac{7}{8}$ in. diameter, the holes in every case being drilled through the various plates in position, the holes in the outer plates being rimed out and countersunk. This was done by the contractor, who first marked the web carefully out, bolted a section of it together, and passed it forward under the radial drilling machines. The flange plates and angle irons were drilled in position by means of portable drilling machines having fourteen spindles.

The vertical struts are each composed of a flat plate between two T irons braced together. The diagonals are also braced together to prevent buckling. The main girders rest on cast iron bed plates with gun-metal strips, the bottom plate of the flange and the gun-metal strips being planed, so as to enable the girder to slide when expanding or contracting. Although differing from the usual practice, this system has been found to act very well, as special notice was taken in the exceptionally hot weather which occurred during the construction of the bridge, the girders expanding and contracting to the extent of $\frac{3}{8}$ in.

The cross girders are 55 ft. 6 in. long, 3 ft. 5 in. deep in the centre, and 2 ft. 8 in. deep at each end. The flanges are curved both on the top and bottom at one end of the bridge, and at the bottom at the other end, each girder varying in shape, owing to the required inclination of the roadway and the maintenance of the requisite headway over the river. The holes in the cross girders are all drilled in a similar manner to those of the main girders, and the work was riveted up and tested in the contractor's yard. The cross girders are suspended from the main girders under each vertical, by 24 in. bolts, 1 in. in diameter, at each end. Each bolt was made in one piece without welding, and tested previous to erection with a dead weight of four tons. After the bolts were screwed up the ends were riveted over the nuts. The ends of the cross girders are surmounted by ornamental castings.

The distance apart of the cross girders is 8 ft. 4 in. from center to center, and each one is capable of bearing a safe load of 50 tons in the center. The roadway is composed of wrought iron curved plates $\frac{3}{8}$ in. thick, supported on short longitudinal roadway girders riveted to the cross girders, each of such girders being capable of bearing a safe load of 15 tons in the center. The parapet is constructed of wrought iron boiler plates with diagonal strips riveted over the joints, bolted to a cast iron moulded plinth. The whole is surmounted by an ornamental moulded cast iron capping with malleable iron spikes. The bridge is so designed that with the heaviest loads that can be brought on it no load will set up a strain in any part greater than $4\frac{1}{2}$ tons to the square inch either in tension or compression.

Nearly the whole of the iron is "Cleveland," and great care was taken in testing all the iron, both for its tensile strength and its elasticity. No iron was used that had a permanent set after 13 tons per square inch of tension was applied, or that broke with less than 24 tons to the square inch. The bridge was designed and executed under the direction of Mr. J. G. Lynde, M. Inst. C. E., Engineer to the Corporation of Manchester; the details having been worked out and the working drawings made by his assistant, Mr. Jerram. The contractors for the ironwork were the Stockton Forge Company, Stockton-on Tees; and for the abutments, Messrs. Ellis and Hinchliffe, of Manchester.—*Engineer.*

A BALL ON A JET OF AIR, STEAM, OR WATER.

By W. F. DURFEE, C.E.

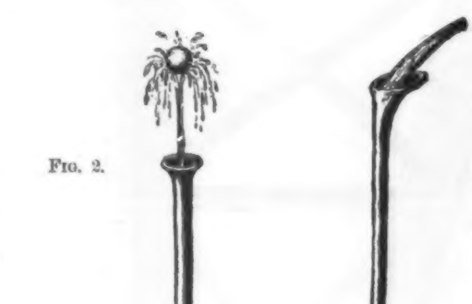
THE numerous communications that have appeared in your own and other scientific journals during the past six months, relative to supporting a ball on a blast of air, are evidence that the interest excited by the curious experiment exhibited at the Centennial by the proprietors of the Westinghouse air brake is not confined solely to the comparative few who witnessed that experiment, but that it is receiving attentive consideration from a large number of persons interested in scientific and mechanical pursuits; and, therefore, a few notes relative to the history of the jet-supported ball may be of interest at this time.

The experiment of sustaining a ball, by means of a vertical jet of steam, water, or air is a very old one, and from it the very much more remarkable illustration of the supporting power of induced currents of air, afforded by the ball and inclined jet, is undoubtedly derived; and though this form of the experiment has been regarded as of recent date, having been brought to public notice from time to time during the last seventy years, it does not seem probable that more than two thousand years, prior to the beginning of the present century, should have elapsed since the first recorded experiment with the ball and vertical jet, without some investigator (either accidentally, as was the case at the Centennial, or purposely) inclining the jet, and thus at once demonstrating that its verticality was not essential to the support of the ball. The exact date of the first observation that a jet of steam, air, or water would cause a ball placed therein to be sustained in opposition to the force of gravity is not known; for Hero, of Alexandria, who lived about 200 years before Christ, states in the preface to his "Pneumatics" (which work contains the earliest mention of this experiment) that he "has thought proper to arrange what has been received from former writers, and to add thereto his own inventions;" but, with a novelty which is not always an attribute of inventors, he fails to designate, among the numerous mechanisms which he describes, "his own" from those of "former writers," and owing to the fact that there are no copies of the works of these worthies in existence, it is at this time impossible to say with certainty whether Hero was the inventor of the jet-sustained ball or not; and all that is known in regard to his claims is that, in the work named, he describes and illustrates it. Fig. 1 is a reproduction of the

FIG. 1.—BALL ON AN AIR STEAM CURRENT.

engraving found on page 149 of Commandine's Latin edition of the "Pneumatics," which was published in 1575. The text accompanying this illustration may be translated as follows: "Balls are made to dance in the following manner: A copper vessel of water having a covered mouth is fired from below; from the cover proceeds a tube having on its end a small hemispherical cup, perforated by the tube. If a light ball is thrown into the cup, it is acted upon by the steam which comes out of the copper vessel through the upright tube, and the ball is elevated so as to be seen to dance." Hero believed that steam was a species of air; for he says, in the preface to the above-named work, that "water, when corrupted by fire, is changed into air;" and as he was well acquainted with the air compression pump, and the elastic force of condensed air, having made use of both (in a number of his recorded inventions, which have for their object the elevation of water for various purposes, among which several forms of fountains are conspicuous), it appears probable that he knew of the fact that a jet of air or water would make a ball "dance" as well as a jet of steam. In many of the

FIG. 2.



older works on architecture and hydraulics, we find the water jet and ball figured, and in the absence of proof to the contrary, it is allowable to suppose that the idea is of direct descent from Hero.

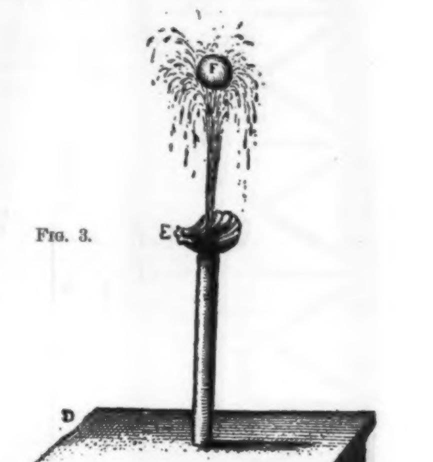
In Flud's "Macrocosmi Historia," published in 1617, we find engravings, of which Figs. 2 and 3 are copies. Fig. 2 requires no explanation; but the motive force in Fig. 3 is not so evident, and, therefore, I translate the explanation as follows: "The quality which cold air has of being expounded by heat, and then lifting and sustaining a solid body, is frequently demonstrated by the following experiment: Water is violently thrown upwards in a jet out of a vessel (A, B, C, D), through the tube E, and by this jet a wooden ball is thrown into the air so that it is seen to dance, and as long as the water is thrown out the ball will dance and leap." The source of the heat used for expounding the air is evidently intended to be the sun, the tube E extending nearly to the bottom of the vessel. This experiment, though it substitutes a jet of water for one of steam, as used in the invention of Hero, is clearly derived from the writings of that mechanician, the final effect produced being the same as is described by Hero, and some parts of the explanation of each writer are identical, and from its being spoken of as a "frequent demonstration," we have a right to believe that it was well known to the learned at the time Flud was writing. The inventions illustrated in the works of Hero and Flud were, without doubt, of great suggestive value in connection with the early attempts to utilize the power of steam.

The first Latin edition of the "Pneumatics" of Hero (translated from the original Greek by Commandine), was published in 1575, and the "Macrocosmi Historia" of Flud in 1617. As these works were printed in the Latin tongue —the universal language of the science of that time—they must have been well known to the learned of the early part of the seventeenth century. At the date of the publication of Flud's work, the Marquis of Worcester was but sixteen years old, and the often-quoted work of De Caus ("Raisons des Forces Mouvantes") was not published until 1624, and the (at this day) less known work of Bronca ("Machine"), in 1629. Therefore, it does not seem at all improbable that the inventive faculties of De Caus, Bronca, and the Marquis of Worcester may have been stimulated, if not inspired, by the perusal of the works of one or both of the older writers before named.

For two hundred years, following the middle of the sixteenth century, water was employed for ornamental purposes in the parks and pleasure grounds of royalty and nobility, and even in the more modest gardens attached to the residences of the wealthier class of citizens, to an extent rarely, if ever, attempted at the present time; nearly all of the most famous artificial fountains, cascades, and *jets d'eau* which are found on the Continent of Europe, having been constructed during the period named. In fact, waterworks were quite the fashion; and, as was natural, a spirit of emulation was excited in the engineers and architects of the time, sparing neither their own ingenuity or their patron's money in the invention and construction of novel forms of water display. Some of the works published in the seventeenth century abound with curious designs for the exhibition of water, many of which are elegant, some elaborately clumsy, and in others the water is so employed as to ingeniously challenge our disgust. From a work published in Latin at Nuremburg, in the year 1664 ("Architectura Curiosa Novu"), containing upwards of two hundred large copper plates, illustrating various forms of fountains, Figs. 4 and 5 are taken, in each of which will be seen the ball supported by the jet.

The author of this work (Georgium Andream Böcklern) was well acquainted with the writings of Hero, and devotes considerable space to a discussion of them. I translate the description accompanying these figures. Fig. 4 is called "A round fountain with seven jets and a leaping ball. To erect

FIG. 3.



this fountain, provide six equally divergent tubes, as a greater number will require a large amount of water; these are placed, as shown, below the water basin, which is provided with turned-up lips drawn out of thin copper and joined together ornamentally; or it may be decorated with skillfully applied color, as you prefer, or may be able. It is proper to observe that there should be no tube erected in the middle (as is erroneously shown in our figure), but a concave cup is preferred, which must be placed concentric with the central hole; this cup, from which the ball leaps, is made of thin copper or brass. Care must be taken in uniting the several parts that the equilibrium is preserved. As soon as the several parts of the fountain are united, the ball in the center of the cup is thrown forcibly upwards by the rush of air which precedes the water, and as it falls back of itself, the jet of water strikes it, and it is again thrown up as was intended. The effect of the ball thus leaping and playing in the air is most beautiful as an ornament to a level garden." Fig. 5 is described as follows: "Another fountain tossing five of the same kind of water balls. This fountain is much more elegant and graceful in appearance than the preceding; in fact, it throws five of the same kind of balls, one from the central and the others from collateral outlets. In the center of the last fountain but one ball is lifted; but in this, others spring from the extremities of the spokes of a wheel-shaped arrangement which requires considerable skill to unite together gracefully. This figure is drawn with the same disagreeable error as is seen in that immediately preceding; it is evidently necessary to omit the drawing out of the tubes in order that the balls may descend into the funnels in the center and at the extremity of the arms. The designer is certainly to blame for this, and must have been naturally ignorant of hydraulic constructions, since where a funnel is required to receive the ball in case it descends outside of the perpendicular, he has placed a tube. Though composed of a great number of parts, the whole of this work may be gracefully assembled together. Note: This large structure requires a great pressure of water, and its main supply pipe should be so calculated as to be large enough to supply the other nine tubes so that the water will flow through them abundantly; experience will advise the constructor in this matter."

Many more examples of the jet-sustained ball might be cited, but the foregoing are sufficient to illustrate its early history. In the latter part of the last century, the "principles of the lateral communication of motion in fluids" were investigated very thoroughly by Professor Venturi, of Modena, and it is the action of the jet on the surrounding air, in accordance with the principles elucidated by him, that the

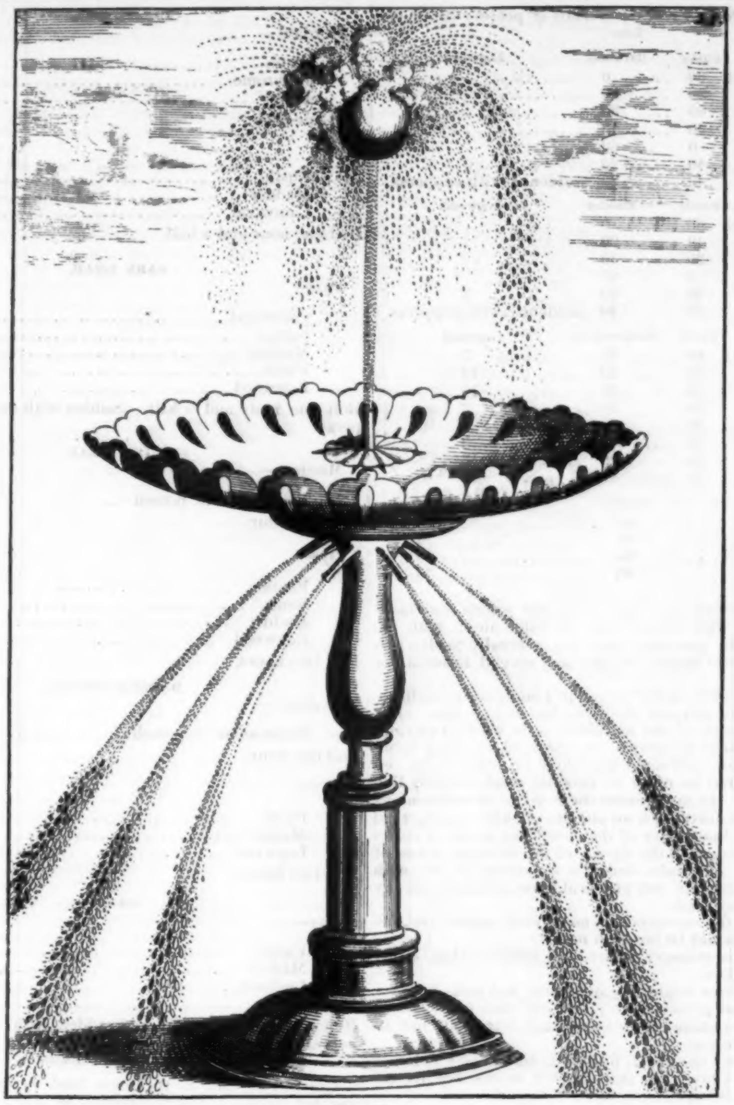


FIG. 4.

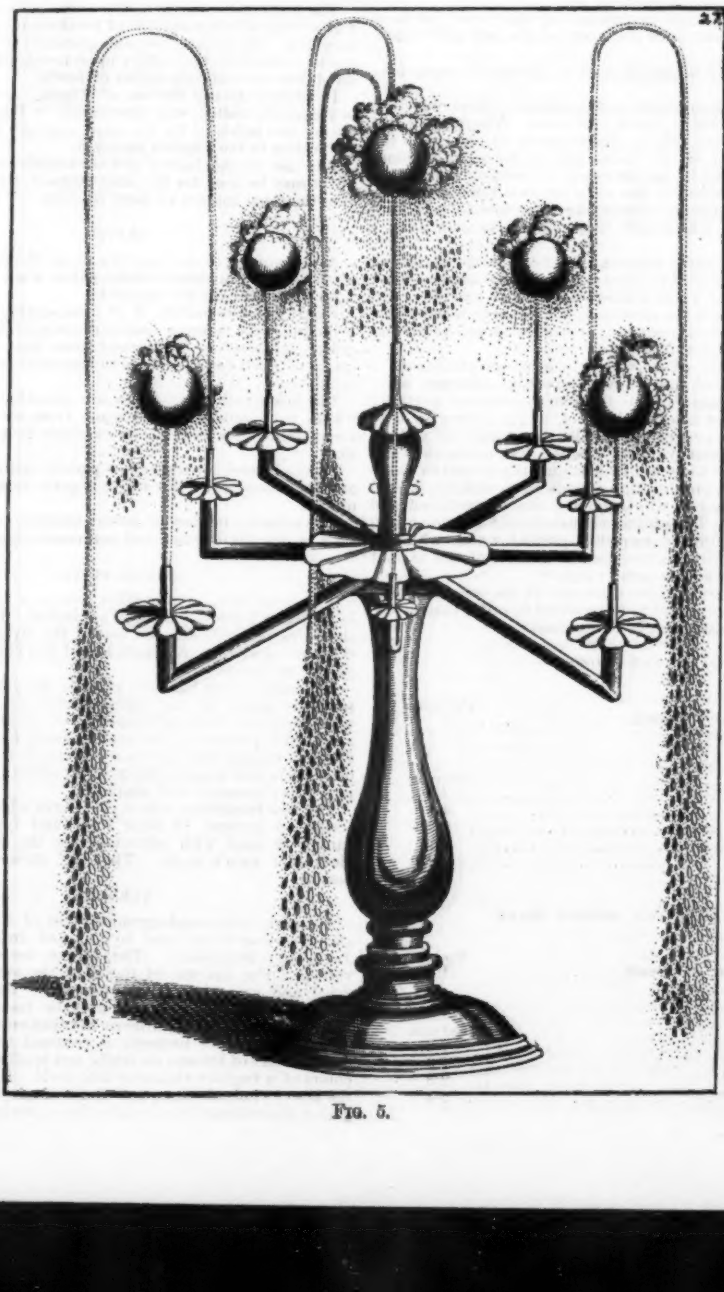
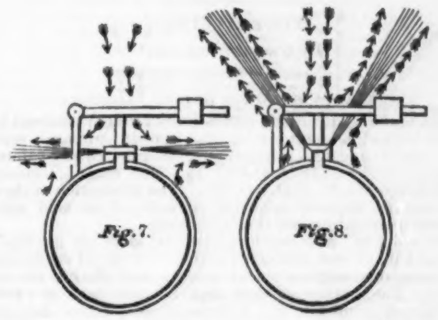


FIG. 5.

Fig. 6.

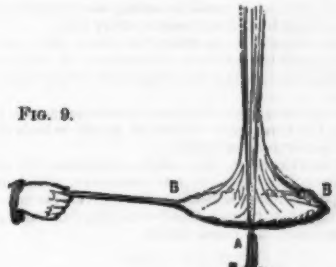
support of the ball in all cases depends. The peculiar action of "induced lateral currents" of air is well illustrated by a simple experiment: Take a piece of ordinary writing paper, roll it around a common lead pencil, and confine its outer edge with paste or gum, and on withdrawing the pencil you have a paper tube. Cut a circle of about 2½ inches across, out of a stiff card, and pierce its center with a hole about ¼ of an inch in diameter, now attach the paper tube to the center of the card by some sealing wax, and near the edge of the side opposite to that occupied by the tube, place three small drops of sealing wax at equal distances from each other; then cut another circle of card of the same size as the first; on putting this card on the drops of wax before named,



inverting the whole apparatus, and blowing forcibly through the tube, as shown in Fig. 6, it will be found to be impossible to displace the card, but as soon as the blast of air ceases the card will drop of itself; this is one form of the "pneumatic paradox" so-called, and the support of the card is due entirely to the action of "lateral" or "induced currents" of air.

*In a communication of M. Clement Desormes to the Academy of Sciences of Paris, dated 4th of December, 1826, he observes "that when steam is compressed in a boiler so that a strong current is made to blow out through a small orifice, that a metal plate or disk on being presented at a little distance from the orifice is forcibly repulsed; but if it is brought near, and pressed so as nearly to close the orifice and cause the steam to escape in a star-like form round the outside of

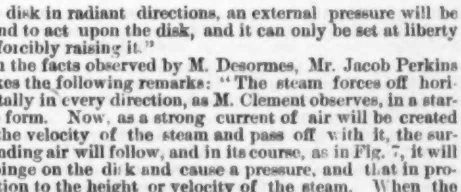
FIG. 9.



the disk in radiant directions, an external pressure will be found to act upon the disk, and it can only be set at liberty by forcibly raising it."

In the facts observed by M. Desormes, Mr. Jacob Perkins makes the following remarks: "The steam forces off horizontally in every direction, as M. Clement observes, in a star-like form. Now, as a strong current of air will be created by the velocity of the steam and pass off with it, the surrounding air will follow, and in its course, as in Fig. 7, it will impinge on the disk and cause a pressure, and that in proportion to the height or velocity of the steam. When the safety valve is so constructed, which is sometimes the case,

FIG. 10.



as to allow the steam to pass off in a horizontal direction, the pressure will be greater than when the valve is conical, which gives a different direction to the steam, as in Fig. 8, making it more difficult for the air to impinge upon the valve."

The peculiar behavior of a ball placed within the influence of either a vertical or inclined jet was noticed by Professor Leslie, of Edinburgh, in 1825, as already mentioned in your columns, and Professor Faraday delivered a lecture at the Royal Institution, some time between the years 1825 and 1829 (of the exact date I am not certain), in which the general action of jets upon the surrounding air, and through this medium upon balls and disks, was discussed. The "pneumatic paradox" in various forms was illustrated in vols. 9 and 11 of the *London Mechanics' Magazine* for the years 1828 and 1829, and received the attention of Professor Hare and other writers in the early volumes of "Silliman's Journal" and the "Journal of the Franklin Institute." In the second

edition of "The Boys' Playbook of Science," published in 1860, Professor Pepper, in speaking of "currents of air that are dragged into an escaping jet of steam," says, "This tendency of the air to rush into a jet of steam was discovered by Faraday, and explains those curious experiments with a jet of steam by which balls, empty flasks, and globular vessels are sustained and supported either perpendicularly or horizontally. If steam at a pressure of about sixty pounds per inch is allowed to escape from a proper jet, and a large lighted circular torch, composed of tow dipped in turpentine, held over it, the course of the external air is shown by the direction of the flames, which are forcibly pulled and blown into the jet of steam with a roaring noise indicating the rapidity of the blast of air moving to the steam jet."

Fig. 9, A, jet discharging high pressure steam. B B, lighted torch held around the escaping steam, the flames from the latter all rush into the former. Egg shells, empty flasks, india-rubber or light copper and brass balls, are suspended in the most singular manner inside an escaping jet of high pressure steam; and before the explanation of Faraday, reams of paper were used in the discussion of the possible theory to account for this effect; and what made the explanation still more difficult was the fact that the jet of steam might be inclined to any angle between the horizontal and perpendicular, and still held the ball, egg shell or other spherical figure, firmly in its vapory grasp.

Fig. 10, A, ball and socket jet at an angle, and discharging steam. The egg shells are supported by the enormous currents of air moving into the jet in the direction of the arrows.

WOOL DYEING.*

By George Jarmain.

(Continued from Supplement No. 75.)

EXTRACTS OF INDIGO (INDIGO CARMINE.)

These are sulphuric acid derivatives of indigo obtained by dissolving indigo in strong, or even fuming, sulphuric acid. The extract, having a purple color, contains chiefly sulphopurpuric acid, $C_{16}H_{10}N_2O_2SC_2$, the blue extract contains sulphindigotic acid, C_8H_5NO,SO_3. The production of these two varieties depends upon the strength of the acid used, and the temperature and time of contact.

The acid, or "sour extract," may be made by gradually adding 1 lb. of well powdered indigo to 12 lbs. of the strongest commercial sulphuric acid, stirring well during the addition. The mixture is then kept for two days, at a temperature of about 140° F. A little of the mixture dropped into water should completely dissolve. The mixture is poured into water, and is then ready for use. The best qualities of indigo and the refined article should be used in these preparations.

The sweet extract is made by neutralizing an acid extract with carbonate of soda and chalk, adding also salt. The sulphopurpuric and sulphindigotic acids form soda salts, which are insoluble in solutions of alkaline salts; the coloring matter can therefore be precipitated, filtered off, and washed. The following process gives a good sweet extract: Add gradually 9 lbs. of the strongest sulphuric acid to 1 lb. of the finest quality of indigo finely ground and sifted, stirring well all the time; set aside for a week at from 60° to 70° F.; then add a solution of 10 lbs. of common salt and 15 lbs. of soda crystals, then ½ lb. of powdered chalk may be added, and the whole well stirred up and thrown upon a filter, and washed with a solution of salt, till the washings run through colorless.

The purple extract is made by using one third as much acid and leaving them in contact only a short time.

These dyes require no mordant for wool; they dye best in an acid bath, and the addition of sulphate of soda is found to be beneficial in clearing the liquid and producing evenness of shade.

They are not used as self colors on woolen goods, but enter largely into the composite colors of goods which do not require to be scoured afterwards.

They are not therefore fast colors, and cannot be compared with indigo colors dyed by vat processes, which possess a degree of permanence which has long given them a deserved popularity, as they remain unaffected alike by heat and cold, sunshine and rain, acid and alkali.

YELLOW COLORS.

The yellow coloring matters which I have now to describe are complementary to those which I have already brought under your notice, as they enable the dyer to complete the range of colors which are employed in the dyeing of cloths, the colors of which are required to be fast and permanent in the sense in which I have used these terms.

We will confine our attention, at the present, to the following yellow colors: Fustic, American bark, flavine, turmeric, Persian berries.

Fustic is the wood of a tree called *Morus tinctoria*. It is imported chiefly from Central America and the West Indies. It is known to the dyer under the names of old fustic and yellow wood. It is prepared for the use of the dyer as chipped fustic, rasped fustic, fustic extract. It is used extensively in all three forms. When the chips are used they are placed in a bag in the boiling water, in the same way as that in which logwood is used. Rasped fustic may be thrown into the pan along with the goods to be dyed.

The tinctorial principles contained in fustic consist of moritannic acid, a pale yellow crystallizable substance, freely soluble in water, morin or moric acid, a crytallizable substance nearly insoluble in water. As moric acid is but slightly soluble even in boiling water, the moritannic acid is the principal available coloring agent in fustic. Fustic gives a yellow color on wool which has been mordanted with chloride of tin, alum, or bichromate of potash, and olive green with a mordant of sulphate of copper or copperas. Fustic is rarely or never used as a self color, but it is very extensively employed along with logwood and the red woods in producing that infinite variety of shades of composite colors, known as blacks, browns, olives, drabs, etc., for which it is eminently adapted. Dyed on wool, with a bichromate of potash or copperas mordant, it produces a fast and beautiful and permanent color.

In the heavy woolen cloth districts, where pilots, beavers, naps, reversibles, fancy trouserings, and such like goods are manufactured, it is more extensively used than any other yellow dye-ware.

Its use and modifying action on other colors, such as logwood and the red woods, are best studied by dyeing equal weights of mordanted wool or cloth with varying quantities of fustic, and of the woods I have just named.

As examples of its modifying influence, I have placed before you samples dyed with the following quantities:

Mordanted with two per cent. bichromate of potash; boiled one hour.

Sample.		Fustic.	Barwood.	Logwood.
1.	Dyed with	60	0	..
2.	"	30	30	..
3.	"	60	30	..
4.	"	20	40	..
5.	"	0	60	..
6.	"	40	20	3
7.	"	40	20	saddened with copperas.

Sample.		Fustic.	Madder.	Logwood.
1.	Dyed with	60	0	..
2.	"	40	20	..
3.	"	20	40	..
4.	"	0	60	..
5.	"	40	20	3
6.	"	20	40	saddened with copperas.

Sample.		Fustic.	Sanderswood.	Logwood.
1.	Dyed with	60	20	5
2.	"	60	20	10
3.	"	60	20	15
1.	"	80	10	3
2.	"	80	30	3
3.	"	80	50	3
4.	"	50	80	3
5.	"	10	80	3

Sample.	Fustic.	Logwood.
1.	60	5
2.	60	10
3.	60	20
4.	60	30

It will be observed that each of the red woods and madder imparts its own special tone of color along with the fustic, and as the practical dyer has generally to dye to a pattern, it is almost useless to give any special formula for particular shades.

My purpose will be better served if I endeavor to indicate to you the specific purpose the dyer has before him, when he makes a selection of the red woods to be used: As a rule, the different shades of brown are obtained by using more than one red color, and sometimes three or four of the red colors are required in order to produce shades exactly like a given pattern. In my opinion there is no department of dyeing which requires such an amount of skill and practical experience, and knowledge of the modifying action of colors upon one another, as in the dyeing of the different tones of blacks, browns, and drabs, and it is wonderful to see with what precision some of our practical dyers can arrive at any particular tone or shade.

In the use of the red woods as modifying agents, the following points should be borne in mind:

1. Camwood is stronger, faster, and brighter than either barwood or sanders.
2. Barwood gives brightness and lustre, but lacks body.
3. Sanderswood gives a more yellow red than camwood or barwood. It contains more color than barwood, but its color is not so bright.
4. Madder gives the finest, brightest, and fastest color; it contains more yellow color than the red woods, but its red coloring matter is superior to those of the red woods.
5. Sumac gives a fine olive yellow shade to brown, and helps to sadden when copperas is used.
6. Logwood in small quantities, say one, two, or three per cent., saddens or dulls the colors of the red and yellow woods.
7. Cudbear has a brightening effect, giving a purple tone to colors.

Incidentally, I may mention a particular effect which is frequently met with in dyeing of wool. The tips of the locks of wool often take a deeper shade of color than the remaining portion of the lock, and as the wool becomes thoroughly mingled in the processes of carding, scribbling, and spinning, to which it has to be subjected preparatory to its final manufacture into cloth, the dyer has to take into account the effect which will be produced by such admixture of color.

In cases of this kind, the general effect produced by the dye may be ascertained by teasing out in the hand a small sample, so that the whole is made as even as possible. On comparing this with the pattern, it will be seen whether the proper effect has been obtained, or whether some additional color, and what color, is required.

There is another effect which is often preplexing to a young dyer; the red and yellow colors have different affinities for the mordanted wool; the red wool colors partially displace the yellow colors. If wool, in the course of dyeing, appears to have received a sufficient amount of yellow, but there is a deficiency of red, and the dyer proceeds to add what he conceives to be a sufficient quantity of red to make up the deficiency, and bring the goods up to sample, he will frequently find that he will then have on too much red and too little yellow. The additional quantities of wood required are added in the form of rasped or ground wood, which is well worked up with the goods, or a solution of the extract may be employed for the same purpose.

The following receipts are examples of the use of several woods which were found to be required in order that a particular shade of color might be obtained:

TAN BROWN.

Mordant—

	Per cent.
Bichromate of potash	1

Boiled for one hour.

Dye—

	Per cent.
Madder	3·2
Fustic	4·8
Camwood	2·
Barwood	1·75
Sumac	2·2

Boiled two hours.

TAN BROWN, REDDER SHADE.

Mordant—

	Per cent.
Bichromate of potash	1

Boil one hour.

Dye—

	Per cent.
Fustic	7·2
Madder	4·8
Camwood	2·8
Sumac	2·4

Boil two hours.

CALIFORNIA.

Mordant—

	Per cent.
Alum	1
Bichrome	1
D.O.V.	½

Boil one hour.

Dye—

	Per cent.
Fustic	25
Madder	2
Camwood	3

Boil one hour and a half.

DARK DRAB.

Dye—

	Per cent.
Camwood	6·5
Sumac	2·
Madder	2·5
Fustic	4·
Logwood	2·5

Boil one hour and a half. Sadden with one per cent. copperas.

OLIVE DRAB.

Mordant—

	Per cent.
Bichromate of potash	1

Boil one hour.

Dye—

	Per cen
Fustic	10·
Sumac	2·
Madder	5·
Logwood	·2

Boil two hours.

MADDER BROWN.

Mordant—

	Per cent.
Bichromate of potash	1

Boil one hour.

Dye—

	Per cent.
Fustic	22·7
Madder	11·35
Logwood	1·13

Boil two hours.

DRAB.

Dye—

	Per cent.
Fustic	1·7
Madder	4·
Cudbear	·1
Sumac	·8

Boil one hour and a half, and sadden with ·2 per cent. copperas.

QUERCITRON BARK.

Quercitron bark is the inner bark of *Quercus tinctoria*, another species of oak indigenous to North America. For the use of the dyer the bark is dried and ground.

The principal coloring matter contained in it is quercitron, a glucoside which is capable of breaking up into a sugar, and quercitin. Both quercitrin and quercitin are yellow coloring matters which, in their effect upon mordanted wool, act very much like the coloring matter of fustic.

In woolen dyeing the use of "bark," as quercitron bark is frequently called, was introduced by Bancroft, to whom we are also indebted for the most original work on dyeing we possess in the English language.

The use of the bark is not as extensive as that of fustic, but it may be used for the same purpose, though it does not give the same amount of body of color.

FLAVIN.

A preparation of bark known under the name of flavin is often used, when shades brighter than what can be obtained with fustic or bark are required.

Flavin consists mainly, if of good quality, of the coloring principle itself, namely, quercitrin or quercitin; its coloring power is therefore far greater than that of bark. One ounce of good flavin is equal in tinctorial power to 1 lb. of bark.

The best qualities of flavin are imported from America, where it is believed to be made from the fresh bark, but there seems to be some mystery about its mode of preparation.

Flavin is used for the yellow part of scarlets and oranges, and for almost any color where a good bright yellow is required.

The coloring matters of fustic, quercitron bark, and flavin may be described as fast and permanent dyes for wool.

YOUNG FUSTIC.

This is the wood of the *Rhus cotinus*, a tree which grows in southern Europe and the West Indies. It is prepared in the form of chips for the use of the dyer. Young fustic contains an astringent principle and two coloring matters, a yellow and a red.

The name fustin has been given to the yellow color, which possesses many of the characteristics of quercitron, but there are some slight differences. On wool mordanted with a tin salt it produces a fine and tolerably fast yellow orange. Its chief employment in woolen dyeing is for the production of scarlets and oranges along with cochineal, for which purpose it is extremely well adapted.

The two remaining yellow dye-wares which I have to describe, on account of their loose and fugitive character, cannot be used with advantage for the dyeing of woolen cloths for men's wear. They are turmeric and Persian berries.

TURMERIC.

Turmeric is the underground stem of *Curcuma tinctoria* and *Curcuma longa*, and is imported from India, China, Java, and Barbadoes. The Indian variety is the most valued. For the use of the dyer the stems or tubers are dried and ground to a fine powder. The powder has a powerful odor, and a strong aromatic taste. The coloring principle contained in turmeric is called curcumin. In wool dyeing, the use of turmeric is confined to the dyeing of a certain class of browns on stuffs, and is often associated with colors of a fugitive character like itself. It finds no use in the heavy cloth districts, and if its employment were altogether discontinued as a woolen dye material, it would be no

* A lecture before the Society of Arts.

great loss to the public who happen to have to wear goods dyed with it. It serves a useful purpose in the laboratory as a test for alkalies, which turn it brown; it is also used as a test for boracic acid.

PERSIAN BERRIES.

Persian berries are the fruit of the buckthorn, and various species of *rhamnus* which grow in various parts of Southern Europe and Asia.

The nature of the coloring matter contained in Persian berries has been the subject of much research, but it is still involved in much obscurity.

It seems, however, to be established that there is a glucoside in Persian berries which crystallizes in yellow silky needles, to which various names have been assigned, such as chrysorhamnin, xanthorhamnin, and rhamnin.

In wool dyeing Persian berries find no use in the heavy woolen trade, the color which they give to mordanted wool not being sufficiently fast to withstand milling and scouring processes. It is, however, often employed as a yellow dye for goods for ladies' wear, such as scarlets and oranges.

SUMAC.

This astringent substance is of considerable importance in the dyeing of certain drabs and browns on woolen goods, as, in addition to the tannin which it contains, there is also a yellow coloring matter which has not yet been studied, but which performs an important part in the production of browns and drabs.

Its action on wool mordanted with bichrome is to produce a fine olive yellow; with a mordant of tin, a bright yellow; and with one of copperas, a dark slate. This last effect is owing to the action of the tannin in the sumac upon the salt of iron.

Sumac, as met with in commerce, is the ground-up leaves and twigs of a tree called *Rhus coriaria*, which grows in Sicily, France, Spain, and other countries. The Sicilian variety is the most esteemed. Dr. Stenhouse has proved that the tannin of sumac is the same as that contained in gall nuts, which is called gallo-tannic acid. This acid gives a blue-black, or slate color, with copperas mordanted material. The compound so formed is the gallo-tannate of iron.

The chief use of sumac to the woolen dyer, however, is for the purpose of dyeing cotton or vegetable matter which may happen to be mixed up with wool.

1. In the form of burls, or threads, or seeds.
2. In union or mixed goods, in which there is a cotton warp with a woolen weft.

The goods, after having been dyed in the ordinary way, as for wool, are steeped in a decoction of sumac in the cold, and then in a solution of so-called nitrate of iron, or of pyrolignite of iron, if the color is black; but for the red wood, yellow wood, and analine colors, the goods which have been steeped in sumac decoction are transferred to a solution of oxymuriate of tin of 2° or 3° Twad.

A tannate of tin is probably formed in this operation, which enables the cotton to take up dyes in the same manner as wool.

There are certain red coloring matters which are extensively used in one branch of dyeing which I will now describe.

COCHINEAL.

Cochineal is the dried body of an insect which lives and feeds upon a cactus; the insect is called *Coccus cacti*, and it is the female which furnishes the dye. The male insect is furnished with wings, but the female is wingless, and remains stationary on the plant. The insects are brushed off the leaves with a soft brush, and dipped momentarily into boiling water, to kill them; they are then dried and sent to market.

There are two principal varieties met with in commerce—(*a*) Silver cochineal, which is coated over with a mealy substance; and (*b*) black cochineal.

I have met with silver cochineal adulterated with sulphate of barium, which at the same time gives it a mealy appearance and adds to its weight. Such a cochineal as this leaves too much ash when burnt.

The present price of cochineal is very low, ranging from 1s. 4d. to 2s. per lb.; this is due partly to the depressed state of the woolen trade, but also to the fact that some of the aniline dyes compete with it.

Cochineal is prepared for the use of the dyer by grinding it in a mill like a coffee mill. The ground cochineal is thrown into the vat along with the goods.

The coloring matter of cochineal is carminic acid, which gives to wool mordanted with chloride of tin a scarlet color, and with alum and tartar a crimson. The color is very bright, and fairly fast and permanent.

On wool its chief use is for the production of scarlets, oranges, and crimsons, rose pinks, and suchlike colors, flannels and serges being the goods mostly dyed with cochineal colors.

The yellow portion of the scarlets is obtained by using flavin, which is the best for the purpose; or young fustic, which answers very fairly; and lastly, Persian berries are sometimes used, but the yellow color obtained with them is not fast.

The mordant used in dyeing scarlets is a salt of tin along with tartar. There is a great diversity of practice among the dyers in the use of tin spirits in scarlet dyeing. Some use the ordinary double muriate or single muriate, others the muriate to which is added one or two per cent. of oxalic acid: some again use a nitrate of tin or a sulphomuriate. I do not know that any special preference should be given to any particular tin spirit, for I have seen equally good results with all of them. When the single muriate will answer, it seems to me unnecessary that the operation should be complicated by the use of a more complex mixture.

When goods are hard woven, a tin spirit which contains but little free acid does not answer well. The color is deposited too much on the surface of the cloth, and the center is often not dyed at all. A tin solution which contains a good deal of free acid, however, enables the color to penetrate better into the center of the cloth, because the colored lake which is formed by the combination of the carminic acid with the oxide of tin is kept longer in solution by the free acid.

The penetration of the color into the center of the cloth may often be accomplished by entering the goods at a temperature below the boil, and heating the bath up to the boiling point very gradually.

A proportion of tartar greater than four per cent. of the woolen material to be dyed has the effect of yellowing the shade of scarlet, the yellowing being in proportion to the excess of tartar.

An increase of the tin mordant, the other materials remaining the same, has the effect of intensifying the shade of color without sensibly increasing the yellow.

In dyeing scarlets and oranges with cochineal, the mordanting and dyeing are done in the same bath, kept at a boil for an hour or an hour and a half; wood cisterns being generally employed for the bath, and the boiling is done by perforated steam pipes.

LAC DYE

is a red coloring matter, which has been manufactured and used in India for centuries. It is now extensively used in this country, along with, or in place of, cochineal. It produces a color on wool which has greater body than cochineal, but not quite so much brilliance.

Lac dye is a secondary product in the manufacture of a gum resin, called lac, which is found on the surface of the small twigs of trees of the genus *Ficus*, on the banks of the Ganges, being deposited there by a small insect called *Coccus lacca*, and belonging, therefore, to the same genus as the cochineal insect.

The crude matter taken from the tree is coarsely powdered, and macerated in hot water; the liquid is then evaporated to dryness; the dry residue is the lac dye, which often contains 50 per cent. of coloring matter.

The identity of the coloring matter of lac dye with that of cochineal has not been fully established, but there is a great similarity in their action on mordanted wool, the chief difference being in the tone and intensity, or depth, of color. Lac-dyed colors are also somewhat faster and more permanent than those of cochineal.

Lac dye is imported in the form of hard cakes, which are ground to a fine powder for the use of the dyer. The dyer works up the powdered color into a paste, with a mixture of hydrochloric acid and his tin spirit, and then adds it to the dye-bath, along with the goods to be dyed; the dyeing is then performed exactly in the same manner as with cochineal.

In practice it is found to be advantageous to combine the brightness of the color of cochineal with the solidity and permanency of lac dye; this is done by dyeing the goods first in a bath of lac dye, and then in a separate bath with cochineal, washing out from the first bath before entering it in the second.

The following are the proportions and cost of dyeing goods on the large scale by this process:

Scarlet.

For 100 lbs. of cloth:

		s.
Lac (mixed, varying from 1s. 6d. to 6d. per lb.), average 1s.		8·08
Cochineal 2s. per lb.		6·00
Argol (110s. per cwt.) 1s. lb		5·
Tin spirit of 45° Twaddell as stannous chloride	1½d. per lb.	2·4
Flavine at 2s. 6d. per lb		·08
Cost of materials for woolen cloth		21·56

AMMONIACAL COCHINEAL.

When cochineal is ground and worked up into a paste with strong ammonia, say 16° of the ammonia gauge, the coloring matter becomes transformed into a new color called carminamide. According to Schutzenberger this change may be represented thus:

$$\underset{\text{Carminic acid.}}{C_9H_8O_5} + NH_3 = OH_2 + \underset{\text{Carminamide.}}{C_9H_9NO_4}$$

This color does not produce red or scarlets, but is employed along with cochineal for the production of rose pinks, crimsons, and suchlike colors.

The mordant which works best with ammoniacal cochineal is the nitrate of tin.

The following are the proportions used on the large scale for the production of a rose pink:

For 150 lbs. cloth:

1½ lbs. ground cochineal, made into a paste with 1½ pts. ammonia 16°, and left overnight.
2½ lbs. ground cochineal.
1½ lbs. tin dissolved in 13 lbs. nitric acid.
5 lbs. argol.

Boil one hour.

EOSINE.

A new dye known under the name of Eosine has recently been added to the list of red dyes, and as it is likely to be a competitor in the production of scarlets on wool, I have thought it advisable to give a short account of it here.

The word "eosine" signifies day-dawn, implying that the color is that of the rosy hue of morning. On silk, the color is that of the rose, but on wool it is scarlet.

In order to produce it, a substance called resorcin, obtainable from a variety of sources, is treated with phthalic acid, whereby a new and fine yellow coloring matter is produced, called fluorescine, on account of its possessing the property of fluorescence in a marked degree. This new body, when treated with bromine, gives the color in question, eosine, which is a bromine of fluorescine. Eosine also possesses fluorescent properties, which you will readily see as I pour the eosine solution into this tall cylinder of water, and illuminate it with the magnesium light.

Woolen goods are dyed with eosine, using alum as a mordant in the same bath.

The goods are boiled for a few minutes with 8 per cent. of alum, and the dye in solution is then introduced at intervals, until the requisite depth of shade is obtained.

The dye will bear soap-washing fairly, but will not stand severe milling. It dyes readily along with aniline and other colors, and promises to be a very useful addition to our present list of dye wares.

ERRATA.—*Claret Brown on Wool.*—For sulphuric acid 25 per cent., read 0·25 per cent. *Brown on Wood.*—For sulphuric acid 5 per cent., read 0·5 per cent.

ADULTERATION OF COCHINEAL.

WE find in the market various kinds of cochineal, whose value, variable enough in itself, is rendered still more uncertain by numerous fraudulent practices.

Cochineal is found adulterated with white lead and with lead filings. Sometimes we come upon a product altogether spurious, made by moulding spent grain, steeped in a concentrated tincture of logwood or peachwood, and agglomerated with mucilaginous matters. It is also sometimes mixed with powdered orchil, peachwood, and dragon's blood.

Red cochineal, the least esteemed kind, after being heated by steam, is shaken up with powdered talc and white lead, to give it the appearance of silver-grain. The white powder given off by this kind, on rubbing it in the hands, suffices to betray this adulteration. Sulphuretted hydrogen rapidly blackens the powder if white lead has been used.

If genuine cochineal is thrown into water, it swells up, when the nine segments which are found in the abdomen of the insect may be recognized. Sham cochineal, on the other hand, is resolved into a paste, when the gum which held its particles together is dissolved.

To detect lead filings the cochineal is ground up with water, when the animal matter floats, and may be gradually poured off.

The raw imitations made with red pastes generally contain earthy matters, which are left behind when a portion is incinerated.

The determination of the value of cochineal is executed by the aid of three methods:

1. *Processes for determining the amount of coloring matter.*—These methods assume that the solvent extracts all the coloring matter from the cochineal, and nothing else, and that the "lakes" precipitated are constant in their composition. Bloch proposes to extract 1 part of cochineal with 250 parts of boiling water, and then precipitates the solution with a standard solution of neutral acetate of lead, dropped in from a burette. The quantity of the solution of lead employed to remove all the color from the liquid, serves to show the comparative strength of different samples.

2. *Dyeing Comparative Swatches.*—Equal weights of clear white wool or woolen cloth (of the same origin) are dyed with equal weights of the samples. Thus for a scarlet the quantities taken may be 15 grains cochineal, 30 of tartar, and 30 of tin composition, with a sufficient quantity of water. (The quantity of the water and of the tin composition must be identical in every experiment. It must also be remembered that wools of different growths vary in what may be called their appetite for colors, some requiring more coloring matter than others in order to produce one and the same shade.)

3. *Colorometric Methods.*—One part of cochineal is extracted with 1,000 parts of distilled water, and the solutions thus obtained from different samples are compared in the colorometer. It must be remembered that different samples of cochineal vary, not merely in strength, but in tone, some, *e.g.*, verging more to an orange than others.

4. *Volumetric Methods.*—Certain processes have been recommended which consist essentially in extracting equal weights of the grain with water, making up each colored solution to an equal bulk with water, and then finding how many degrees of some standard solution, dropped in with the burette, were sufficient to destroy the color. Penny's well-known process is an instance of this kind. They all labor under the capital defect that the quantity of the standard liquid consumed depends not on the coloring matter alone, but on other organic bodies which may be extracted along with it.

Ammoniacal cochineal is sometimes adulterated with cheap lakes. These frauds may be detected by the quantity of mineral matter left on incineration.—*Technologiste.*

A CURIOUS NEW SPONGE, KALLISPONGIA.

PROFESSOR E. PERCEVAL WRIGHT describes a beautiful little sponge found growing on the fronds of some species of red seaweeds from the coasts of Australia. The largest specimens measure not three millimeters in height. The sponge consists of three distinct and well marked portions: firstly, a small basal disk; secondly, an elongated stem, on the summit of which expands the third portion, or capitulum. The disk is button-shaped, flat, and is formed of an irregular horny framework, two to three times as broad as the stem. The stem varies in height, and presents the appearance, in some cases, of a series of margined rings, some twenty in number, fastened together one on the top of the other; in others the margins of the rings will be more prominent, and the bodies of the rings will be, as it were, more deeply sunk. In both these cases the horny framework is of a more or less evenly latticed character, the longitudinal lines of the lattice being very prominent. The head portion, in its natural state, probably presents a more or less spherical form, perhaps slightly flattened on the summit, with an indication of being divided into four nearly equal parts, the open space between these leading into the body cavity of the sponge. In some of the specimens the head portion nearest to the stem seems to have been formed of a somewhat denser framework than the upper portion, so that while being pressed this upper portion has been fractured across. The framework here is of a densely reticulated kind, in appearance reminding one of the reticulated network of the intracapsular sarcode in Thalassolampe, or of the tissues met with in some Echinoderms. This sponge has been called *Kallispongia Archeri*. The wonderful mimetic resemblance which it bears to some Crinoid forms can scarcely be overlooked. Leaving the texture and composition of the skeleton mass for the moment out of view, and simply looking at its outline—the circular disk-like base, the stem—the profile of which is absolutely the same, except as to size, as that of the pentacrinoid stage of *Antedon rosaceus*, and the slightly cleft head, the resemblance is very great.

WHY SILK HATS ARE DEAR.

SILK hats cost this spring from $4 to $7, a reduction of $1 from last year's prices. But, because of a 65 per centum duty on silk plush, the silk hat must remain a costly luxury, and double the cost of one in England and France. Not a yard of silk plush is now made in this country, as the dyeing is not understood, and a New Jersey firm lost $100,000 in unsuccessful experimenting, the American black plush turning brown under the hot iron. Plush is now $6 a yard, that was $3 before the war, when finishing that now costs $6 and $7 was $3. Like gin, the hat body improves with age, but this cannot be taken advantage of, as the styles are so changeable, which, however, enables us to compete with the "blasted foreigner" in hats generally. Probably more imitation English hats are sold in Boston than in any other part of the country; folks can't discriminate, and one of our local dealers with foreign experience says there is no need of importing; that we can make up a tall hat full as well as the English, and, as for felt hats, the American manufacturers can beat the world.—*Springfield Republican.*

A LONDON jeweler has just completed, after years of search to get the gems together, a diamond necklace of the value of $135,000. It contains twenty-five stones, the largest being some twenty-four carats in weight, with none less than five carats, all of the purest water.

[Popular Science Review.]

EVIDENCES OF THE AGE OF ICE.

By Henry Woodward, F.R.S., F.G.S., Etc.

Only a few years ago it was looked upon as an article of faith among geologists that the whole globe was once in a molten, incandescent state, and that the conditions of temperature now prevailing on the surface of the earth had been produced in process of time by the slow and gradual cooling of the once fused and glowing mass. But whatever may be the unknown heat of the deeper strata, that of the surface results solely from the great source of heat, the center of attraction of our planetary system—the sun.

The oscillations between heat and cold that we experience from day to night, and from summer to winter, all depend on the laws of absorption and radiation of heat given off by the sun to the earth, or radiated by the earth into stellar space.

If the earth were a globe of perfect regularity, presenting on its surface no contrast of land and sea, plateaux and plains, snow and verdure, a nearly equable distribution of climates would be established over its whole extent, and one could exactly measure the degrees of heat by those of latitude.

But such we know is not the case. Every place has its own climate. Such variations depend on the elevation of land above the sea; the position of a place, whether inland or on the coast; the direction and height of its mountain chains; the extent of its forests, savannahs, and cultivated lands; on the width of its valleys, the abundance of its rivers, the outline of its coast; on marine currents, prevalent winds, clouds, rain, fogs, etc; these varied causes constitute, together with the latitude, what is called "the climate of a country."

Undoubtedly the most important climatal phenomenon is that of temperature, for to heat we probably owe all the movements of the atmosphere which we call winds. Parts of the earth become overheated, and these put in motion the whole system of atmospheric currents; these too give to the winds the moisture destined to be dispersed as clouds, and to fall again on the earth as snow and rain.

The impulse to all these movements of air and water is given by the sun's rays; and on this luminous body all the life of our planet depends. To the facts, then, that the earth is so uneven in its surface configuration, that its land and water are so very irregularly distributed, and that it receives an unequal share of solar heat varying with the seasons and the latitudes, we owe that infinite variety of climate by which it is characterized.

One country near the polar circle receives more warmth than does another situated at a less distance from the tropics; one region of the temperate zone is hot in comparison with certain spaces in the equatorial zone. And in each place the temperature continually varies and oscillates under the action of winds, currents, and all the other agencies which affect climate; and when indicated by lines on the surface of the earth, an inextricable network is formed, of which we can only recognize the principal traits.

Fifty years ago Humboldt first conceived the idea of uniting by lines all those parts of the earth's surface having the same annual average temperature.

These imaginary lines traced on the circumference of the globe are called isothermal lines; they give the thermal latitude, which differs widely from the geometrical latitude.

While the lines of degrees traced every 69½ miles apart are parallel to the equator and perfectly regular, the isothermals are contorted into numerous and often sharp curves over all parts of the earth.

The thermal equator (or the curve of the greatest average heat, on each side of which the temperature gradually decreases towards the poles), lies almost entirely in the northern hemisphere, which is warmer than the southern.

The district of greatest heat lies between 10° and 60° E. longitude, and between 15° and 30° N. latitude; that is to say, it is the area to the east and west of the Red Sea, and embracing the greater part of that narrow gulf, and also that of Persia.

The district of greatest cold lies between 120° and 140° E. longitude, and between 60° and 80° N. latitude, along the course of the river Lena, the principal river of Siberia, covered during many months of the year by snow and ice; within the frozen mud and ice-cliffs at whose mouth have been found the entire carcasses of the mammoth and the woolly rhinoceros.

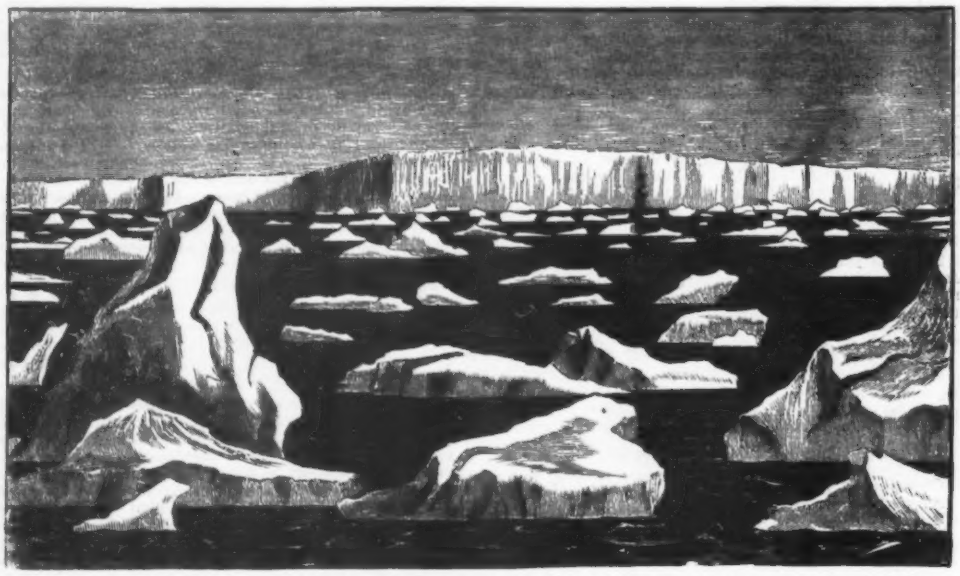
All these sinuosities of the isothermal lines over the earth's surface are caused by similar isolated areas of a higher or lower temperature, which deflect them in a greater or less degree from a straight course.

Thus, in the southern hemisphere, where the continents are diminished gradually towards the south, and where the moderating influence of the ocean tends to eliminate all climatic differences, the lines of equal annual temperature seem to be pretty regular, and in the Antarctic Ocean they may be considered parallel to the degrees of latitude. The most marked curves of these southern isothermals are developed immediately to the west of Africa and the west of South America, where the influence of the currents of cold water flowing towards the equator from the Antarctic Ocean is most visibly demonstrable.

In the northern hemisphere the sinuosities of the isothermal lines are much more marked than in the southern, and cut the degrees of latitude at all angles. One of the highest of these isothermal waves is that which rises in latitude 45° N., off the coast of Halifax, Nova Scotia, passes to the south of Newfoundland, ascends in a northeasterly direction past the southeast coast of Iceland, attaining its summit about latitude 65° N.; it then bends down to Drontheim, Stockholm, and Moscow, falling again nearly to latitude 45° N. in Central Asia.

But whatever may be the sinuosities of the lines of equal temperature, they all indicate a more or less rapid decrease of heat between the equator and the two polar zones.

In the interior of continents, the chief modifications of climate are produced by mountain ranges and winds; on coasts and islands the climate depends on ocean currents and winds.



THE EDGE OF THE ANTARCTIC ICE-SHEET, WITH ICEBERGS. From a Drawing by Sir J. C. Ross.

Happily for England, we enjoy here what is called an "insular climate." There are special reasons why the climate of the British Isles is so much milder than that of any other place in the same latitude, and we may with advantage consider these exceptional circumstances before proceeding further. Take, for example, two parallels of latitude at the present day. Off Little Belle Isle, in the month of July, 1864, Mr. J. F. Campbell records the temperature of the air at 48°, water 40° (wind south when the temperature was taken), and icebergs in sight. Mr. Campbell passed bergs 400 ft. deep and 200 ft. long, and many others of far larger size, some being 150 ft. above the water. Belle Isle is in the same latitude as London.

In 1831, Mr. Redfield states that the harbor of St. John's, Newfoundland, was completely blocked by ice so late as the month of June. This is 2° further south than the port of Liverpool, and yet one never heard of the port of Liverpool being blocked by ice even in January. Again, the limit of constantly frozen ground which extends to the southern border of Hudson's Bay (where ice is found in digging wells in summer, at a depth of 4 ft. below the surface) is in the same latitude as London. Nairn, on the desolate and frozen coast of Labrador, is in the same latitude as Dublin; yet the former has only a mean temperature of 28°, whilst Dublin has a mean temperature of 49°, or nearly double the warmth of Nairn. The cause of this great disparity in the relative temperature of places lying in the same parallels of latitude is to be found in the prevalence of certain winds and oceanic currents, which cause the isothermal line to bend northward so many degrees in passing from west to east.

The ocean current in which we are especially interested is that mighty stream which issues from the Gulf of Mexico, flows in a northeasterly course across the Atlantic, and is commonly known as the "Gulf Stream."

Since 1842, when the energetic Captain Maury, of the United States Navy, first drew the attention of the American Government to the importance of preparing "wind and current charts," the Gulf Stream has not wanted observers and historians. This remarkable oceanic current is about 25 miles in breadth off Cape Florida, and it increases to 127 miles off Sandy Hook, whilst its depth diminishes from 1,000 to 200 ft. and under as it proceeds northwards. From the American Coast and from the banks of Newfoundland it is deflected across the Atlantic, reaching the Azores in about 78 days, after flowing nearly 3,000 miles. Our own islands enjoy a portion of its warmth; and even Spitzbergen, in latitude 79° north, feels its influence, and before its warm breath the glaciers are stopped abruptly in their descent to the sea.

Mr. Croll has estimated the total quantity of water conveyed by the Gulf Stream to be equal to that of a current of water 50 miles broad and 1,000 ft. in depth, flowing at the rate of 4 miles an hour, with a mean temperature of 65°. Before its return from its northern journey, he concludes it has cooled down at least 25°. Each cubic foot of water, therefore, has carried from the tropics upwards of 1,500 units of heat, or 1,158,000 foot-pounds.* Principal J. D. Forbes has calculated that the quantity of heat thrown into the Atlantic Ocean by the Gulf-Stream on a winter's day would be sufficient to raise the temperature of the air which rests on France and Great Britain from the freezing point to summer heat.

At the very time the Gulf Stream is rushing in greatest volume through the Straits of Florida, and hastening to the north, a cold counter-current is descending from Baffin's Bay by Davis Straits to the south with almost equal velocity. This current flows inshore on the North American seaboard, and also beneath the Gulf Stream, but does not mingle with its waters.

The Gulf Stream is, of course, only one of many oceanic currents, but to us it has a pre-eminent degree of interest. It brings us genial showers, borne by the southwesterly winds, from the surface of its warm and steaming waters. It carries the temperature of summer even in the depths of winter as far north as the Great Banks of Newfoundland, and there maintains it in the midst of severest frosts. It is the presence of this warm water and a cold atmosphere in juxtaposition which gives rise to the "silver fogs" of Newfoundland, one of the most beautiful phenomena to be seen anywhere in the domains of the Frost King. Every west wind that blows crosses this stream on its way to Europe, and carries with it a portion of this heat to temper the inclemency of the northern winter. It is the influence of this stream upon the climate that makes Erin the "Emerald Isle," that clothes the shores of Albion in evergreen robes, and encourages the myrtle and magnolia to flourish at Mount Edgecombe in the open air all the year; it carries West Indian seeds to the Scottish Isles, wafts the floating pteropod shells to the latitude of Iceland, and renders the fauna of Spitzbergen richer than that of any other Arctic realm.

But all earthly advantages are transient, and not even the Gulf Stream can be expected to be always so partial to us as it is to-day. Indeed, geologists are aware that formerly, owing to the subsidence of that narrow belt of land, the Isthmus of Panama, at one time, and probably by the subsidence of the Mississippi Valley at another, the Gulf Stream has more than once been diverted from our coasts, and our islands were, as far as they were above water, glaciated even as the coasts of Labrador are at the present day.

Let us briefly consider the evidences on which geologists have relied in writing this latest chapter in the geological history of our island. These evidences are most abundant and varied; some of them, indeed, lie close to our own doors, and may easily be studied and examined. I allude to the great series of deposits known to geologists as "glacial deposits," and which have resulted either from the action of glaciers or icebergs, or some modification of them. These may be classified as follows:

I.—1. Roches moutonnées.	II.—5. Erratic blocks.
2. Striated rock surfaces.	6. "Kames," "eskers," and sandy gravelly drift.
3. Boulder clay and "till."	
4. Moraines of valley glaciers.	7. Stratified clays with Arctic shells.

In some instances these can be divided into—

I. Those due to glaciers and coast ice, whilst the land was greatly elevated (1 to 4).

II. Those due to the sea and icebergs whilst the land was greatly depressed (5, 6).

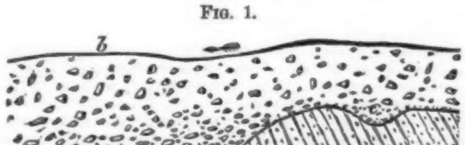
But many of them are so altered and reconstructed that it is exceedingly difficult to attribute them to one or other of these divisions. What evidences, then, have we to-day?

"The general surface of a great part of the British Islands," says Mr. James Geikie, "excluding the center and south of England, has a smoothed contour, which is now generally recognized as the work of land ice

"Hills, valleys, and knolls of rock have been ground down and have received that characteristic flowing outline which ice alone, of all natural agencies, can produce (*roches moutonnées*). When, moreover, we strip off the superficial cover of detritus and examine the surface of rock underneath, we find it covered with the well-known grooving and striation such as are met with by the side of every modern glacier in the Alps.

"These markings are not disposed at random, but run in more or less parallel lines. And when we examine them over the length and breadth of the country, we discover that they point away outwards in every direction from the main masses of high ground, indicating that the ice which produced them covered the land in a deep continuous sheet, like that of Greenland, and that it moved outward and downward from the high grounds to the sea. So vast was the mass of ice that it swept over considerable hills, smoothing and striating their sides and summits."

Fig. 1.



Section at East End of Neidpath Tunnel, Peebles.

a, Silurian rocks; *b*, till, showing arrangement of stones on the lee side of the rock; *c*, gravel in a hollow under the till. The arrow indicates the direction in which the till has traveled.

To this period Professor Ramsay refers the general erosion of the present lake-basins of Britain.

Another feature of the surface-geology of the country dates from the same period—the widely distributed boulder clay, or "till." This deposit is not at all likely to be confounded with any other It consists of a mass of unstratified clay, with blocks and boulders of stone stuck into it promiscuously, the whole seeming to be the result of an irregular "pell-mell" carrying forward and deposition of the materials (see Figs. 1 and 2).

The color and general composition of the mass may vary according to the nature of the rocks from which it has been derived. Thus, in a region of dark, carboniferous shales, the boulder clay is leaden, gray or black; in one of Old Red, or Triassic sandstones, it is red. In the Chalk country it is quite full of bits of chalk, and is hence called the "chalky boulder clay."

The stones in the clay range in size from mere grains of sand up to masses a yard or more in length. Wherever the rock of which they consist has been of a kind to receive and retain surface markings, the stones are found to be covered with ruts and striæ, which run for the most part in the direction of the long axis of each stone.

There can hardly be any doubt that these markings have been produced under a sheet of land ice similar to that which covers the whole interior of Greenland at the present day.

* According to the above estimate of the size and velocity of the stream, 5,575,680,000,000 cubic feet of water are conveyed every hour by the Gulf Stream, or 133,816,320,000,000 cubic feet per day. The calculations of Sir John Herschel and Captain Maury make the amount still greater.

This great inland ice-sheet that at places advances to the coast and thrusts the snouts of its glaciers into the sea itself, giving rise to enormous icebergs, covers the entire continent of Greenland, save a few dozen miles at most of coastline, which remain free. It forms on its seaward face precipitous cliffs of ice about 200 feet high covered with a thin layer of earth and stones, but rises at first rapidly, afterwards

FIG. 2.

SECTION OF GLACIAL DEPOSITS IN THE SETTLE AND CARLISLE RAILWAY CUTTING AT CULGAITH.

T, upper till; *S G*, sand and gravel; *C*, laminated clay; *T'*, lower till; *R*, rock. Length, 40 feet.

more slowly, to a height of several thousand feet. During Professor Nordenskiöld's expedition to Greenland in 1870, he made an excursion upon this inland ice sheet with one companion, Dr. Berggen, and two Greenlanders.* They penetrated thirty miles into the interior in four days, attaining an altitude of 2,200 feet above the level of the sea.

No moraine matter was observed on the surface of the ice; but everywhere, under the influence of the sun's rays, this immense ice-field was in motion internally, and large rivers and lakes on its surface descended through the ice in roaring torrents, by "swallow-holes" 2,000 feet deep, to join the streams which flowed beneath.

The ice-sheet which some geologists believe to have been once co-extensive with our island, covering it from its sea-level to the highest peak of its loftiest mountains in Wales or Scotland, was, it is assumed, only a repetition of the present state of Greenland, or, on a larger scale, of what one may see taking place to-day on the Alps and the Himalayas and other mountain ranges, whose heads are covered by perennial snows. For the process of reduction of temperature takes place in a corresponding ratio, whether we sail to the North Pole with the *Alert* and *Discovery*, or with Professor Tyndall scale the heights of the Matterhorn or Monte Rosa.

If, then, temperature decreases with altitude above the sea-level, an elevation of our island would produce the same effect upon it as if we could transport it bodily to the latitude of Greenland!

It is well to keep these facts clearly before the mind, because, among the numerous explanations offered by our leading geologists, this question of the *relative elevation* above the sea-level has not had that prominence given to it in the discussion which it deserves. The results of *altitude* have in fact been confounded with those of *latitude*.

The stones that occur in the boulder clay spread over so many counties in England differ widely in character; and, from a study of these, it is possible to determine the direction in which the ice-sheet moved, and the centers of dispersion whence the boulders were derived.

Wherever the surface of the rock is of sufficient hardness it is everywhere polished, rounded, and striated in a precisely similar manner to what is seen to be taking place in valleys occupied by glaciers at the present day; whilst the boulder clay is the finely comminuted particles worn down to powder, like the grains of wheat into flour, by the glacial millstone, and poured out in a turbid stream, or pushed along as a great rampart of stones and rubbish forming the terminal moraine, as we see it at the foot of the Mer de Glace, above Chamounix, or, at times, as in Greenland, pushed into the sea itself, for in Lancashire this deposit is associated with fragments of marine shells.

Where this is the case, the finer particles have been carried away and re-assorted by sea-currents and mixed with marine organisms, as in the Clyde glacial beds; the shells indicating arctic conditions.

During one period of the glacial epoch we had a great depression of the land; to such an extent, indeed, that these glacial deposits, associated with marine shells identical with species now existing, have been found in Cheshire up to a height of 1,200 feet. On Moel Tryfaen, near the Menai Straits, fifty-seven species of shells of marine mollusca have been obtained (all indicative of a colder climate than that of our present sea) at a height of 1,300 feet above the sea.

It was at this period, no doubt, that icebergs and floes of ice laden with boulders and other foreign material were transported from the western and northern highlands and dropped their burdens, on melting, over and about where London now stands, especially in the neighborhood of Finchley and Muswell Hill, where vast numbers of erratic blocks have been observed, and numbers of transported fossils have been collected by the late Mr. N. T. Wetherell, F.G.S., and other geologists.

Various theories have been brought forward in explanation of the glacial epoch. Among these that of James Croll, F.R.S., of the Scottish Branch of the Geological Survey (also adopted in the main by Mr. James Geikie, F.R.S.), has been largely advocated. It is based on the calculation that at certain unequal periods, owing to the eccentricity of our earth's orbit around the sun, the earth is occasionally somewhat further distant from the sun than at the present time (98,500,000 miles, instead of as at present, 90,500,000; or, to be exact, 8,641,876 miles more distant). The last occasion Mr. Croll puts at 200,000 years ago.

The other cosmical cause advocated by Mr. Croll is the slight variation in the polar obliquity of our earth, which varies through long periods between 23½° and 24½°.

When the earth, from these two causes combined, became subject to a slight variation in its two hemispheres, which would give to one 7½ days more of the sun's presence in one tropic than the other now enjoys, then Mr. Croll concludes the ice on the more favored pole would melt, and that on the less favored would increase; and this cause alternating, would give rise at long intervals to alternate glacial epochs in each hemisphere, accompanied by displacements of the earth's center of gravity, and a rising of the waters of the sea combined with an increase of ice at the pole.

Mr. James Geikie, in his book on "The Great Ice Age," actually makes two glacial epochs with an interglacial period between them, into which period he introduces—1st, a milder cold temperate climate, with the mammoth, the woolly-coated rhinoceros for denizens of our forests, and the great bear dwelling in our caves, the winters still severe; 2nd, a warmer sub-tropical climate, with the retreat of the arctic mammalia northwards, and the advance from the south of the hippopotamus, the cave-lion, the hyæna, and palæolithic man, evidenced by the rude flint implements found in valley gravels.

Then followed another cold period, before which the southern mammalia disappeared, and were again succeeded by arctic animals. Even these, however, migrated southward, leaving the land to be again overspread with ice and snow.

Mr. Geikie admits that there were not unfrequent shiftings in the distribution of land and sea, but these do not seem to him to have been the chief causes of these climatal changes. After this second cold period, Mr. Geikie next introduces the submergence of the British Islands to 2,000 feet; gives it a final refrigeration, in which period the drifts and angular erratic blocks were scattered over the south of England, and over North Germany and Russia, and the Swiss glaciers were augmented. Then Britain for the last time—

Arose from out the azure main,

to be again re-forested and re-peopled, this time by the moose-deer and the cariboo or reindeer, the arctic fox, the lemming, and the marmot; and Neolithic man became the denizen of our caves and woods, and made pictures of the animals he there saw and hunted.

FIG. 3.

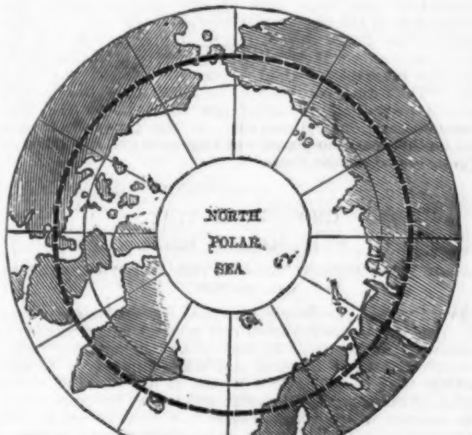


DIAGRAM OF NORTH POLAR SEA.

A marine area almost surrounded by land. To contrast with Fig. 4, the South Pole having a land surface entirely surrounded by ocean.

The only considerable change which Mr. Geikie proposes to introduce at this period is the severance of our island from the continent, and the complete insulation of Britain.

I hope it may be possible to simplify this chapter of our Glacial epoch, and here I am glad to say I have the high authority of Professor Nordenskiöld, who has visited both Spitzbergen and Greenland more than once, that from the evidence of fossils obtained in a succession of beds in arctic latitudes, he is led to the conclusion that there has not been in past geological times a periodical alternation of warm and cold climates on the surface of the earth.

In Eocene Tertiary times sub-tropical conditions prevailed in the latitudes of London and Paris, and both plants and animals betokened a temperature at least as high as that of North Africa.

FIG. 4.

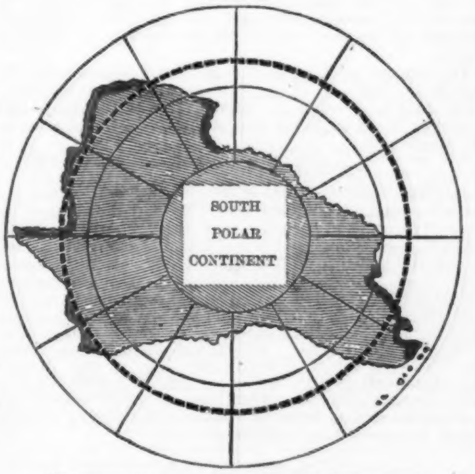


DIAGRAM OF THE SOUTH POLAR CONTINENT.

To illustrate the vast land area forming the gathering ground for the great Antarctic icebergs. The darker parts along the margins of the South Polar land indicate those portions which have been actually coasted along, such as South Victoria Land (with Mounts "Erebus" and "Terror"), Enderby Land, Trinity Land, etc.

Since that period, through Miocene and Pliocene formations, we are able to trace a gradual lowering of the temperature of our islands by the more temperate sub-arctic and arctic character of their faunas, and what traces remain of their floras also.

Then came the Glacial period, first initiated perhaps by the diversion of the Gulf Stream, caused by the subsidence of the Isthmus of Panama, or more probably by the opening up of a course for its waters up the great central valley of North America, down which the Mississippi river now flows, and which, save a narrow strip between Lake Superior and Hudson's Bay, is nowhere more than 800 feet above the level of the sea; this, if lowered, would give a direct course for the Gulf Stream up to the northwest coast of Greenland and to Smith's Sound.

Afterwards, by the elevation of the land only 600 feet, this island would be united to the continent on the one hand, and to Ireland on the other; whilst its shores would extend outwards to the margin of the plateau of Ireland, seventy miles to the west, and from beyond the Shetlands in the north to near the northwest of Spain in the south.

Probably the elevation was far greater, for the British Isles have a powerful line of volcanic disturbance running down about the meridian of 6° west longitude, which in the western Highlands and the north of Ireland was active down to an exceedingly late geological period (Miocene).

If it be necessary to call in extra-mundane causes to explain the great increase of ice at this glacial period, I would prefer the theory propounded by Dr. Robert Hooke, in 1688; since by Sir Richard Phillips and others; and lastly by Mr. Thomas Belt, C.E., F.G.S.; namely, a slight increase in the present obliquity of the ecliptic—a proposal in perfect accord with other known astronomical facts, and the introduction of which involves no disturbance of that harmony which is essential to our cosmical condition as a unit in the great solar system.*

Such an increase in the obliquity of our earth's axis would result in an increase of ice, not at one pole at a time, as proposed by Mr. Croll, but at both poles simultaneously: a condition which accords with the fact that with our present obliquity we have ice at both poles now; the larger supply at the antarctic being purely caused by the fact that in the southern hemisphere we have a polar continent surrounded by a circumpolar ocean (Fig. 4), whereas in the arctic we have a polar sea surrounded by a circumpolar land (Fig. 3).

The ocean is the great evaporating dish, the continent the condenser; hence the larger glaciers of the southern pole, where the ice-wall of the land ice, which in Greenland stops some miles inland, here comes down to the sea itself, plowing up the sea bed, and spreading out its terminal moraine in the ocean.

What length of time has elapsed since the Glacial epoch occurred we cannot pretend to say; Mr. Belt estimates the date to have been 20,000 years since, Mr. Croll 200,000 years ago. We may, therefore, I think, rest content with the geological evidences of a modification of the climate afforded by the remains of glaciers and icebergs and the zoological evidence of a former change in the distribution of the mammalia telling the same story.

I believe the musk-sheep and the mammoth were both præ- and post-glacial animals, and that the mammoth survived till after the climate became milder, but that he was a scarce animal from that time. The musk-sheep lives on still in Arctic North America. The sabre-toothed lion (*Machairodus*) is so rare with us, as a fossil, that we may fairly assume he belonged to the earliest præ-glacial cave period, as did the panther, lion, lynx, hippopotamus, two species of rhinoceros, and one variety of mammoth (*Elephas antiquus*).

If the Esquimaux of Greenland live on the borders of the ice fields, and many animals flourish there also, and birds are most abundant, it is fair to assume that on the retreat of the ice, man and animals advanced and occupied all the fertile valleys, and pursued the chase as the Lapps, Finns, Tungusians, Samoiedes, American Indians, and Esquimaux have done in our times further north.

We speak of the stable land; but we must always remember that, whether the land is upheaved by volcanic energy from beneath, or the sea level lowered by the abstraction of water and the piling up of snow and ice on the circumpolar lands, the effect is the same to man as an observer. This, however, we know, that in the latest geological period—the Tertiary (both Miocene and Pliocene) early man may have been a witness of some of the largest exhibitions of elevatory force on our earth's surface; for in these later periods the great Himalayan, Persian, Carpathian, and Alpine chains have been upraised, carrying high upon their flanks, as a part of their structure, beds of Nummulitic limestone of Middle Eocene age.

If, then, the Himalayas with Mount Everest have been raised up to 29,000 feet above the sea in this recent period, our islands may have well oscillated a few hundreds of feet; and trivial as such phenomena may be when compared to the elevation of the great backbone of the Asiatic Continent, nevertheless these lesser changes have for us an interest which even the lofty mountain masses do not possess. Nor is it an idle question to ask—"Was man present to witness these modifications of our islands?" He may have been, judging by his implements. Certainly in France and Switzerland he saw and killed the musk-sheep and in France he also saw the mammoth alive and pictured him. But the reindeer and the horse were the chief objects of the chase, as their remains testify. Nor is it at all improbable that these nomadic cave dwellers are represented to-day by the tribes of the Arctic seaboard, who have retreated with the amelioration of the climate which compelled the reindeer to go further north to give place to more southern animals and hunters, and these in time to civilized man himself.

THE TEMPERATURE OF THE SEA.

AT a recent meeting of the Royal Geographical Society, Dr. W. B. Carpenter, C.B., F.R.S., delivered a lecture on the temperature of the deep-sea bottom and the conditions on which it depends. Dr. Carpenter remarked that the distribution of the temperature on the deep-sea bottom is a subject which, in its relations to geology and biology, it would be impossible to overestimate. Animals which were to be found on the surface of the sea only in some places were in others to be found at depths 1,000 or 2,000 fathoms. This particularly happened in the soundings between the north of Scotland and the Faroe Islands. On the other hand, often within a few miles were to be found waters of a very different temperature, and with animal life of a totally different species. The distribution of temperature was obviously connected with that remarkable physical feature which Sir J. Herschel remarked—the continuity of the oceans. When the subject was taken up some nine years ago the general idea on the temperature of the ocean was, that it was uniform, and about 39°. This was supposed to be in harmony with several explorations which had been last made, and the theory that water which had been cooled down to 39° would gravitate to the bottom and there remain. That notion was approved by Sir John Herschel, but now it was known that the pressure of the deep sea upon the bulbs of thermometers was such that, if it did not break down, it so altered their shape that the quicksilver was forced up at a distance of, say, three miles some 8° or 10°, and the instruments of Sir James Ross were known to have registered degrees which had since been proved to be in excess of what really was the temperature at certain depths in certain places. Dr. Hooker,

* The Greenlanders turned back after two days, but Nordenskiöld and his companion pushed on two days' journey further.

* In Jupiter the axis is nearly perpendicular to the plane of its orbit. In Saturn the obliquity is 29°. In Mars it is 30⅓°; in Venus it reaches the extreme of 75°, so that its tropics actually overlap its arctic circle, and there are no temperate zones. The earth has an inclination of 23½°. It is estimated that its axis may have been inclined as much as 35½° during the glacial period.

..., had written that the observations of 1839 had been of the greatest service to scientific research. Now, however, from the use of protected instruments, the temperature was more accurately ascertained, and the Challenger explorations of 1868–70 had shown that the temperature, which at 500 fathoms had been believed to be 32°, had been subsequently found to be only 29°. In the South Atlantic the water over the bottom was generally as low as 32°, while in the North Atlantic it rarely fell below 35°. This problem of the low degree of water in the tropical area, where warm water might be expected, and a higher degree in the polar region, where one might look for a colder temperature, was a very curious one. The Red Sea had been known to rise in temperature, in summer time, as high as 100°, and never fell below 70°. Fresh water could not be cooled below 39°, and when congealed by a winter temperature it might be explained as the mean winter temperature of the locality. When warm water was below the surface it rose until it came within the local influence, and being cooled to 39°, sank, and gave place to other water. So it went on as long as warm fields of water existed, and when it froze it was when a uniform temperature had been established throughout. Any one could determine this for himself by observing the convection currents in water boiling over a fire, the lower field of water being first heated, rising to the surface, and giving place to cold, which became heated and rose in its turn. It was but a transposition of conditions. In the Swiss lakes the warmer temperature was at the surface, while in the artificially-heated water it commenced at the bottom. In the Mediterranean the water down to a depth of 2,000 fathoms at one part preserved a temperature of 55° throughout, but a cold body of water of 3·5° rose in the center close to the surface. In explaining this and how the application of cold to any part of a body of water would cool down the whole mass, Dr. Carpenter said that it had been called the downward hypothesis; but he felt it impossible to reconcile the temperature of the deep sea basis to any other cause than that of gravitation. If it was only known what were the peculiar communications between the great polar areas it would be possible almost to predict what temperature to expect at the bottom of the deep sea in any parts.

HOW THE EARTH MAY BE DESTROYED.

THE catastrophe in the stellar system—the conflagration of a star—which caused so much commotion in astronomical circles a few months ago, is made the subject of an article in "Belgravia" (March) by Richard A. Proctor. He says that this catastrophe happened probably a hundred years ago; the messenger which brought the news to us, though travelling at a rate sufficient to circle the earth eight times in the course of a second, had traversed millions upon millions of miles before reaching us last November. If a similar accident happened to our sun the creatures on that side of the earth turned towards him would be destroyed in an instant, and the rest very quickly afterwards. The heavens would be dissolved, and the elements would melt with fervent heat. The question is asked whether the earth is in this danger, and whether warning would be given of the coming destruction. The answer may be gathered from the facts mentioned in the article. There have been other solar conflagrations before that which was made known last Fall. The first on record—observed by Hipparchus—occurred 2,000 years ago. It was seen blazing in full daylight, showing that it was many times brighter than Sirius, the blazing dog-star. It was called a new star because it had ever been invisible until its conflagration made its light temporarily visible. The next new star (or stellar conflagration) appeared in the region of the heavens between Cepheus and Cassiopeia three times, A.D. 945, 1264, 1572, and is expected to be seen on fire again before long. This star remained burning at its last appearance for sixteen months. It appeared larger than Jupiter and brighter than Sirius. It did not attain this lustre gradually, but shone forth at once in its full size and brightness as if it had been of instant creation. In 1596 Fabricius observed a new star in the neck of the "Whale" constellation, and in September, 1604, a new one was discovered in Ophiuchus. In 1670 a new star appeared in the constellation Cygnus, remaining visible for nearly two years. In 1848 another was seen, which has continued in existence since its apparent creation. By the aid of the telespectroscope—an instrument combining the telescope and the spectroscope—it was found that the increase in the star's light rendering the star visible was due to the abnormal heat of the hydrogen surrounding that remote sun. But it could not be so easily decided whether this hydrogen was aglow with the heat of the star or whether absolute combustion was in process. In other words, was it as a red-hot piece of iron or like a red-hot coal? These star conflagrations, it is believed, are caused by contact with other heavenly bodies—meteoric flights traveling on eccentric paths, or those in attendance on the comets. The meteors attendant on a comet continue to follow in its path years after the comet has disappeared. The tail of the comet of 1843 must actually have grazed our sun. Newton's comet nearly approached it. At any time we might be visited by a comet mightier than either, traveling on an orbit intersecting the sun's surface, followed by flights of meteoric masses enormous in size and many in number, which, falling upon the sun, would excite his whole frame to a degree of heat far exceeding what he now emits. We have evidence of the tremendous heat to which the sun's surface would be excited in such a case. In 1859 two meteoric masses came into contact with the sun. The downfall of these two bodies only affected the whole frame of the earth at the very time when the sun had been thus disturbed. Vivid auroras were seen where they had never been seen before, accompanied by electro-magnetic disturbances all over the world. In many places the telegraph struck work, the signal-men received severe shocks, and at Boston a flame of fire followed the pen of Bain's electric telegraph, which writes the message upon chemically prepared paper. This was the effect of two meteors. The effect of a comet, bearing in flight many millions of meteoric masses upon the sun—should that take place—can be understood. Our sun seen from some remote star whence ordinarily he is invisible would shine out as a new sun for a few days, while all things living on our earth, and whatever other members of the solar system are the abode of life, would inevitably be destroyed. If a comet came out of that part of the constellation Taurus, arriving in such a time as to fall upon the sun in May or June, the light of the sun would act as a veil, and we should be instantly destroyed without knowing anything about it. If it fell in November or December, we should see it for weeks, and astronomers would be able to tell us when it would fall upon the sun. The disturbance upon the sun would be temporary, but there would be no students of science left to record the effects. The chances are largely against such an accident. Our sun is one among millions, any one of which would become visible to the eye under such an accident, yet during the last 2,000 years less than twenty such catastrophes have been recorded. Mr. Proctor moreover reassures us in another way. He says in effect that all but one of these conflagrations have appeared in the zone of the Milky Way, and that one in a region connected with the Milky Way by a well-marked stream of stars; that the process of development is still going on in that region, but that if there be among the comets traveling in regular attendance upon the sun one whose orbit intersects the sun's globe it must have struck before the era of man, and that in our solar system we may fairly believe that all comets of the destructive sort have been eliminated, and that for many ages still to come the sun will continue to discharge his duties as fire, light, and life of the solar system.

THE PLANET VULCAN.

PROFESSOR DAVIDSON was at the summit of the Sierras on March 21st to 23d, on the look-out for the possible transit of Vulcan over the sun's disk; reports that the weather was favorable except in the afternoon of the 21st and late on the afternoon of the 22d, but no signs of a planet was visible, although one spot and disturbed area was seen on the 21st and 22d, and a second disturbed area appeared on the 23d. These were important as indicating what size of spot could be observed, and it is believed that had the planet appeared with a diameter of five seconds of arc it would very readily have been seen. The disk of the sun is reported to have been very sharply defined during the greater part of the time of observation. In this city, Mr Pratt of the Coast Survey made similar search for the planet; and at San Bernardino, W. G. Wright of that place, with less favorable weather, observed through the three days. The former saw the spot on the 21st and the disturbance on the 23d, and the latter saw the spot on the 21st. These observations indicate that, at the time of observation on this coast, no planet was visible on the sun's disk.—*Mining and Scientific Press.*

GEOLOGICAL TIME.

By T. MELLARD READE.

PRESIDENTIAL ADDRESS BEFORE THE LIVERPOOL GEOLOGICAL SOCIETY.

IN this paper, Mr. Reade has used the analyses of river waters to determine the amount of mineral matter carried in solution from the land. He finds that the amount of water run off the area of England and Wales annually is 68,450,936,960 tons, equal to 18·3 inches in depth out of 31·988 inches of mean rainfall, leaving 13·7 inches for evaporation. The amount of solids in solution is 8,370,630 tons, or 12·23 parts in every 100,000 of water—in which are about 9·50 parts of carbonate and sulphate of lime and magnesia, 1·66 of chloride of sodium, 0·08 of nitrates, and 0·99 of alkaline sulphates and carbonate of soda, silica and sesquioxide of iron. Estimating the solids in solution at 15 cubic feet to the ton, the amount of denudation by solution would be ·0077 feet per century, or one foot in 12,978 years. Prestwich arrived at one foot in 13,200 years, for the amount of carbonate of lime which the Thames carries off from the Chalk, Upper Greensand, Oolitic strata and Marlstone. The Thames, estimating the discharge at 8 in. per annum, and the total solids at 29·26, as given by Prestwich, removes 147 tons per square mile per annum; and the denudation over England 143·5 tons.

Mr. Reade makes similar calculations for the rivers of Europe, and finds that the Rhine removes about 92·3 tons per square mile; the Rhone about 232 tons; the Danube about 72·7 tons; giving an average for the three rivers of 90 tons per square mile. The Garonne removes 142 tons per square mile; the Seine about 97 tons. From these data the conclusion is reached that probably over the world about 100 tons of rocky matter are dissolved by rain per English square mile per annum; of which, as near as can now be estimated, 50 tons may be carbonate of lime, 20 tons sulphate of lime, 7 silica, 4 each carbonate and sulphate of magnesia, chloride of sodium, and 6 alkaline carbonates and sulphates.

The amount of detritus brought down annually by the Danube is about $\frac{1}{3068}$ of the water, or three times the calculated amount of solids in solution; that of the Mississippi according to Humphreys and Abbott, $\frac{1}{1571}$ of the water. Mr. Reade adds:

"If we were to take the solids removed mechanically at six times those in solution, which is a very high estimate, we should have over the whole of the globe 600 tons of denuded matter annually per square mile. Taking the sedimentary crust of the earth at ten miles thick throughout—a moderate estimate—and allowing for the denudation of the sea and the amount added to sediments by volcanic ejections, matter equal to one-third that which is denuded from the land, we should have annually removed and deposited matter equal to 800 tons per square mile of land surface, or 40,800 million tons annually. The total surface of the globe is 197 millions of English square miles. A cubic mile of rock at 13¼ feet to the ton would weigh 10,903,552,000 tons, so that to cover the whole surface of the globe one mile deep with sediment from the land at the rate of 800 tons per square mile of land surface, would take 52,647,052 years, or 526 million years in round numbers for ten miles deep."

COLORED HAIL AND SNOW.

By DR. A. T. MACHATTIE, F.C.S., etc.,

Lecturer on Chemistry, Glasgow.

DURING my residence in Canada, nine years ago, a fall of hail and snow of a peculiar character occurred, and the facts seem to me worthy of being recorded.

At London, in the Province of Ontario, the fall began between 8 and 9 P.M., on February 24th, 1868, and was accompanied by a violent storm of lightning and thunder, and a strong gale from the southeast. At Sarnia, in the same province, on almost the same line of latitude, and more than 50 miles distant from London, similar phenomena were observed, but the fall of hail and snow did not begin till about 7 A.M. on the 25th of February. The observations in London were made by me personally; in Sarnia, by a friend.

In some places the dark-colored shower seemed to consist of snow; in others, of hail; and my Sarnia correspondent described it as being more like "frozen rain" than either of the above.

One square yard of the dark hail or snow, when melted, deposited rather more than 5 grains of a dark grey (almost black) powder. This amount is equivalent to almost exactly 1 ton per square mile. I could not learn with certainty over what extent of district the shower fell, as a sudden thaw very soon removed all traces of its presence. Considering, however, that it was observed at two places 50 miles distant from one another, and at one of them (Sarnia) it was known to extend over 10 miles square, I assume that a belt 50 miles long by 10 miles broad is not a very excessive estimate of the district covered; but, of course, it may have been much less or much greater, and the dark matter may not have been present in uniform quantity—most probably not. The above estimate would give no less than *five hundred tons* of the dark matter, and, at any rate, there is little doubt that the quantity was large considering the source.

On examination under the microscope, I found the dark substance to consist mainly of vegetable matter far advanced in decomposition. This result has since been corroborated by Dr. James Adams, of Glasgow, who further expressed the opinion that the vegetable matter consists principally of the remains of *cereals.*

From the circumstance that the surface of the ground and all shallow waters in Canada were frozen for months before the shower fell, it would appear that the dark matter could hardly have come from any local source. It is more likely that it came from some distant southern district of America, where the ground was neither frozen nor covered with snow; this, however, is mere conjecture.

It will be observed, from the above remarks, that the dark matter referred to in no way resembles the siliceous-shelled microscopic organisms which have been so often observed to fall on the Atlantic Ocean and elsewhere. It is this unusual character, as well as the quantity of the above dark shower, that induces me to draw attention to it. There was no difficulty in obtaining it *pure*, because the shower was deposited in three distinct strata: (1.) Pure snow. (2.) The layer containing the dark substance. And (3.) A layer of pure snow when the violence of the storm had abated.—*Chemical News.*

FERMENTATION.

DR. ANDREWS P. AITKEN, Chemist to the Highland and Agricultural Society, lately delivered a short address on the subject of fermentation. It was a process, he said, that had been known from the earliest times, but until recently it had been very little understood. Passing in review the various theories of fermentation, he dwelt especially on the two which a few years ago were so hotly debated between Liebig and Pasteur. Liebig maintained that fermentation was due to an instable chemical compound called a ferment, which in the act of splitting up or undergoing a chemical change, was able to communicate that molecular change to some other bodies capable of receiving it. These were called fermentescible bodies, and that the free action of the oxygen of the air was necessary to the process. Pasteur, on the other hand, declared fermentation to be the result of living germs, which multiplied in a saccharine liquid at the expense of the oxygen dissolved in it, but when that was used up they took oxygen from the saccharine liquid, and in so doing caused it to be decomposed into alcohol, carbonic acid, etc. When fungi, such as blue mould, grew on the surface of a liquid containing sugar, albumenoid matter, etc., it used the atmospheric air, and no sugar was decomposed; but if the fungi were then plunged beneath the liquid, it still continued, though with difficulty, to live, and in doing so, decomposed the sugar into alcohol and carbonic acid. Fermentation was therefore due to the prolonged vital activity of the fungus, which was cut off from a supply of free oxygen. This was an exhausting process, and the vitality of the ferment required to be restored by occasional admission of air, which enabled it to multiply rapidly, and thereafter produce a more vigorous fermentation.

The lecturer then described a few of the more common ferments, and explained the condition of their vitality, and the methods employed to study their character and history.

In the course of his address he referred specially to the fermentation of beer, and as it contains some points of considerable interest to brewers, we quote it in full.

When barley has been steeped in water for some time, and then spread, damp, on a floor at ordinary temperature, it germinates. From three to seven little rootlets appear, and the embryo within the seed begins to grow. During this time the starchy matter in the seed is being converted into sugar. The barley is then dried in kilns, and is called malt.

The malt, when crushed and dissolved in water, yields the sweet wort or malt liquor of the brewers.

It has long been known that if this wort is exposed for some time to the air it begins to ferment, *i.e.*, it puts on an appearance of boiling; bubbles of carbonic acid gas continually rise in it, and the sugar of the wort is converted into alcohol. This process of fermentation immediately stops if the liquid is boiled. If wort is boiled in a tube or flask, and if the vessel is hermetically sealed, or even plugged with cotton wool, while boiling, the wort may be allowed to cool, and will never ferment, but remain quite unaltered for any length of time. In the latter case there is free access of air to the wort through the cotton wool, so that it cannot be the air alone which causes the wort to ferment.

A little examination of a fermenting liquid will show a sediment, or scum, which, when examined through the microscope, will be found to consist of cellular bodies, having a definite shape and in an active state of growth. The most familiar substance of that kind is the yeast plant (*Torula cerevisiæ*), composed of small, roundish, nucleated cells, which when put into fresh wort immediately bud and grow with great rapidity, the wort in the meantime entering into brisk fermentation.

A minute germ of *Torula* is sufficient to begin the process, and as these germs are floating abundantly in the air, they cannot fail to alight on wort when exposed to the open air. This is the cause of spontaneous fermentation.

When the yeast plant alone is added to wort, either spontaneously or otherwise, the products of the decompositions of sugar are alcohol and carbonic acid, along with notable quantities of succinic acid and glycerin.

In all commercial beer there are found, however, lactic acid and a little acetic acid. These are impurities, and Pasteur, in his beautiful research on the maladies of beer, has traced their origin.

They are caused by the action of other germs than that of the yeast plant—the lactic and acetic ferments, which, floating in the air, have sown themselves in the sweet liquid along with the yeast, and have set up fermentations different from that of the yeast plant. Sour beer turned beer,

ropy beer, putrid beer, etc., have all been found to be associated with the growth of special germs. Each malady has its germs, and if care be taken to exclude the germs, the malady does not appear.

Cold weather kills or benumbs, and prevents the multiplication of these minute germs, hence in cold weather beers are much less subject to disease, and the colder months of the year are best suited for brewing purposes. In this country it is possible to brew in warm weather, from one great cause among others, that our brewers make use of the high fermentation, *i.e.*, fermentation by means of a species of yeast that tends to float on the top of the wort.

The bubbles of carbonic acid on rising to the surface are entangled in the yeast, and form a thick layer of froth, termed "the head," which, covering over the fermenting wort, protects it to a considerable extent from contamination by germs of disease falling on it from the air. The practice which prevails in most breweries of beating back "the head" into the wort, so as to oxygenate it, and hasten the fermentation, by bringing the yeast into better contact with the wort, contaminates the wort with the germs of disease that had been intercepted by "the head." The mischief thus brought about would be greatly lessened if brewers would skim off the upper surface of the head before beating it back. On the Continent, where the lower fermentation is employed, it is impossible to brew good beer in summer.

The lecturer remarked that for practical brewers one of the most valuable results of Pasteur's research was the method he proposes for obtaining a pure yeast. He found that by the growth of yeast alternately in pure wort and pure solution of sugar, the germs of disease were killed, and the germs of yeast, which were hardier and immensely more numerous, survived.

This simple experiment was one that could easily be carried out by brewers on a large scale, and with careful attention to the purity of the yeast (and the microscope presented a means of testing its purity), it seemed probable that good sound beer might be brewed as easily in warm as in cold weather.

There were, no doubt, many other precautions required to be taken, but it was quite certain that the researches of Pasteur had thrown a flood of light upon the *rationale* of the process of fermentation, and brewers would do well to make themselves acquainted with his works, that they might be able to escape much of the loss incident to their trade.

SILICOTUNGSTIC ACID AS A REAGENT FOR ALKALOIDS.

DR. RICHARD GODEFFROY has ascertained the fact that silicotungstic acid is probably the most delicate reagent for alkaloids, nearly all of which, even in highly dilute, neutral, or faintly acid solutions, yield a precipitate with an aqueous solution of this acid. The sensitiveness of the reaction was tested by experimenting with the hydrochlorates of quinia, cinchonia, and atropia, with the following results:

An aqueous solution of quinia hydrochlorate gave, with a few drops of an aqueous solution of silicotungstic acid, a distinct precipitate, even in dilutions containing only 0·004 per cent. of the alkaloidal salt. Opalescence could be still observed in presence of only 0·002 per cent., corresponding to $\frac{1}{50000}$ of quinia hydrochlorate.

A solution of cinchonia hydrochlorate was rendered cloudy in presence of only 0·0005 per cent., or $\frac{1}{200000}$ of the alkaloidal salt.

A solution of morphia hydrochlorate was made opalescent in presence of 0·0065 per cent., or $\frac{1}{15385}$ of the salt.

None of the known alkaloidal precipitants, such as platinic chloride, potassium iodohydrargyrate, iodized potassium iodide, etc., show any reaction in such high dilutions.

The precipitates produced by silicotungstic acid are soluble with more or less difficulty in concentrated hydrochloric acid; they are decomposed by solution of caustic potassa, which causes the separation of the alkaloids and the formation of an easily soluble potassium silicotungstate. On shaking the precipitates with caustic ammonia, they are at first dissolved to a clear solution, which, however, soon becomes cloudy from separation of silica. Ignition of the precipitates leaves behind an insoluble mixture of silica and tungstic anhydride (anhydrous tungstic acid).

Silicotungstic acid is best prepared by boiling sodium tungstate with freshly precipitated gelatinous silica. To the resulting solution is added solution of mercurous nitrate, which causes a precipitate of yellow mercurous silicotungstate, which is well washed with water upon a filter, and decomposed by an equivalent quantity of hydrochloric acid. Silicotungstic acid goes into solution, and mercurous chloride (calomel) remains behind. The clear filtrate is evaporated, to drive off the excess of hydrochloric acid, and furnishes, on spontaneous evaporation, large, shining, colorless octahedra of silicotungstic acid, which effloresce in the air, melt at 36° C., and are easily soluble in water or alcohol. We are therefore enabled to precipitate the alkaloids even in alcoholic solution, by using a similar solution of the acid. Marignac has found that this acid does not produce insoluble or difficultly soluble precipitates with any metallic salt, and Godeffroy adds that only cæsium and rubidium salts—but both even in very dilute solutions—are precipitated by it, and that it produces in a neutral solution of ammonium chloride a white precipitate, which is very difficultly soluble in large quantities of water.—*Arch. de Pharm.*

AKADEMIE DER WISSENSCHAFTEN, VIENNA.

L. BOLTZMANN, "Notes on some Problems of the Mechanical Theory of Heat." The author shows from mathematical considerations that the specific heat of liquids, brought into consideration in the theories with regard to the properties of their saturated vapors, is neither that by constant pressure, nor that by constant volume, being slightly greater than these both. The remainder of the communication is devoted to proofs of the mechanical theory of heat based on the principles of analytical mechanics.

F. LIPPICH, "On the Theory of Electro-dynamics." Taking Neumann's proposed potential expression for the ponderomotory action of two closed, similar, lineal currents on each other as the foundation of electro-dynamics, the author seeks to establish its correctness more directly than has hitherto been done, and bases the theory on the following four grounds: (1) The principle of the conservation of energy is applicable for the pondero-motory action of any two similar closed currents, fixed or movable; (2) this action is dependent only on the form, intensity, and relative position of the currents; (3) the influence upon each of the two currents is composed of the influences of the individual components; (4) the force exerted by one of the currents on the other is entirely uninfluenced by the presence of other currents.

J. LASCHMIDT, "On the Thermal Equilibrium of a System of Bodies with reference to Gravitation." The author proves that in a vertical column of gas the temperature of the upper strata is less than that of the lower, and then considers the probable effect of gravitation on the thermal equilibrium of the universe. The conclusions arrived at are that the history of the various solar systems consists of a succession of epochs marked in turn by the concentration of matter, evolution of heat, radiation of heat, cooling, renewed increase in the stock of heat, dispersion of the heated masses, and condensation.

F. EXNER, "Diffusion of Vapors through the Films of Liquids." The results of experiments with the vapors of benzine, chloroform, alcohol, carbon bisulphide, and ethyl sulphide, show that vapors obey the same law as permanent gases with regard to the diffusion through absorptive films, viz., the velocity of diffusion of different vapors is inversely proportional to the square roots of their densities, and directly proportional to the co-efficients of absorption for the respective liquids forming the films.

A. LIEBEN and G. JANECEK, "On Normal-Hexyl-alcohol and Normal Œnanthylic Acid." Fermentation caproic acid was changed successively into caproic aldehyd, hexyl-alcohol, hexyl iodide, and œnanthylic acid. The results of the investigation show that normal hexyl-alcohol is identical with the hexyl-alcohol obtained from the essential oil of *Heracleum giganteum*, and that normal œnanthylic acid is identical with the acids obtained from the oxidation of œnanthol, and from the oil of *Heracleum*.

L. LIEBERMANN, "On Metanitro- and Metamido-benzacetylic Acid." The author describes the preparation of these two acids, and shows their structure to be as follows:

$C_6H_4(NO_2).CO.CH_2.COOH)$ and

$C_6H_4(NH_2)(CO.CH_2.COOH)$,

the latter being isomeric with hippuric acid, but distinguished from it by the double substitution in the benzine skeleton, and by the fact that the substitution does not take place in the amido group.

"Action of Animal Charcoal on Salts." The author finds that the attraction of the charcoal for bases is much stronger than for acids, and that a large variety of salts are decomposed through its action, the acid being released in amounts which could be determined quantitatively. Nearly all chemicals compounds are kept back in part by the filtration of their solutions through animal charcoal.

"Solubility of Sulphur in Acetic Acid." All varieties of sulphur are found to be moderately soluble in warm concentrated acetic acid, although almost insoluble in ordinary dilute acids. By cooling or evaporation the sulphur is deposited in the form of long, beautiful prisms.

"Detection of Fuchsin in Wine." The strongly marked characteristic absorption band between yellow and green, yielded by fuchsin solutions, permits of its detection, even in a dilution of 1 : 300,000.

J. v. JONSTORFF, "Changes in Molecular Form." Crystals of iodine, preserved in a glass flask, and exposed for eight years to variations of temperature amounting to 0—24°, increased in diameter from 2·3 m.m. to 4·5 m.m. The change was probably due to volatilization and subsequent condensation on the larger specimens. Amorphous phosphorus preserved under water and exposed to the same conditions as the iodine, was examined after a lapse of nine years, and found to contain a number of perfectly formed crystals of the ordinary form of phosphorus.

E. v. FLEISCHL, "Estimation of the Internal Resistance of Galvanic Batteries." This is accomplished by joining together the two similar poles of two elements of the battery to be measured, and then comparing the resistance in this combination with a known resistance by means of Wheatstone's bridge.

F. HOFMEISTER, "On Some Reactions of Amido-Acids." The author has examined the conduct of glycin, leucin, sarcosin, asparagin, aspartic acid, glutamic acid, and taurin, with a variety of reagents, and found that with the exception of taurin they yield a number of similar reactions, which can be used as group reactions for their detection.

"Copper Salts of Tyrosin, Aspartic Acid, and Glutamic Acid." The composition and solubilities of these salts are described very fully.

"Solubility of Copper Oxide in Alkaline Solutions of the Amido-Acids." Quantitative experiments show that two molecules of glutamic acid, tyrosin, leucin, sarcosin, and glycin, and one molecule of asparagin and aspartic acid, are each able to hold one atom of copper in a state of solution in an alkaline liquid. The solubility is probably dependent on a chemical process and the formation of a double salt.

G. GOLDSCHMIDT and G. CIAMICIAN, "A Modification in the Determination of Specific Densities of Vapors." The authors determine the volume assumed by the vapors of a weighed substance after passing into the gaseous state by the weight of the displaced mercury. Satisfactory results were obtained with ether, phenol, naphthalin, and resorcin.

F. EXNER, "Galvanic Expansion." The author's experiments show that the elongation experienced by a wire during the passage of a galvanic current is due simply to the heat developed by the current.

J. PULUI, "Diffusion of Vapors through Earthenware Plates." Experiments with alcohol, ether, and water show that their vapors diffuse through plates of porous earthenware, inversely as the square roots of the densities, with very slight variations of Graham's law. The velocity of diffusion increases with the temperature. The author shows, also, the incorrectness of Dufour's assumption, that dry air diffuses more rapidly than moist air by actual experiment.

FIREPROOF CURTAIN.

MR. E. W. GLOVER, of Malden, Mass., has invented a fireproof curtain which successfully resisted the severe tests to which it was subjected at the time when it was publicly tested some time since. It is intended to remain flat, and to be hoisted and lowered bodily. The surface next the audience is of a chemically prepared canvas, which cannot be made to blaze, no matter how intense the heat. The other side is of wire gauze 40 mesh, and between these two parts is a dead air space of from three to four inches in depth. At the top, on the stage side, a spray of water is to be thrown upon the wire gauze, and trickling down, will entirely fill the interstices between the meshes, so as to render it absolutely air-tight, preventing any draught of air between it and the canvas, while the steam which is constantly generating in case of a hot fire will aid in checking the progress of flame, and will so exhaust the air inside the curtain as to leave nothing to sustain combustion. Tests were made by turning upon it a gas jet which took the full supply from a 30 burner meter. This intense heat thrown against the wire gauze, both when dry and wet, failed to perceptibly warm the canvas two inches away. A piece of ordinary manilla paper was held close to the back of the wire two and a half minutes before igniting, although the only separation from the flame was the wire gauze, then perfectly dry. It took seven minutes before this 30 burner flame forced directly upon a piece of the prepared canvas could burn a hole through it, and then the canvas was only carbonized, and cracked because of its weakness and the impact of the flame. The method of treating the canvas is this:

1. A light solution (so as to reach and cover the interior fibers) of tungstate of soda, density 50, mixed with one third silicate of soda, is rubbed in by machinery and then dried.

2. The canvas is then treated with a saturated solution of tungstate of soda mixed with one half silicate of soda and a saturated solution of alum.

3. A coating of silicate of soda is applied of the consistency of ordinary mucilage in density, mixed with whiting.

WEARING PROPERTIES OF ALUMINIUM.

DR. C. WINKLER, of Freiberg, in a paper upon the resistance of aluminium to atmospheric and chemical agencies of change, makes the following observations: Aluminium has always been regarded as a metal possessing but little resistance to exterior influence of change, and that it would readily be attacked by both acids and alkalies. The relative cost of zinc, aluminium, and silver, are as 1: 200: 400; or, considering the weights of the metals named, as 1: 67: 530. To test in practice the comparative wearing qualities of aluminium, Herr Winkler has made a number of spoons respectively of silver, pure aluminium, and German silver. A spoon of each material above named was accurately weighed on February 1, 1876, and all were put into daily use under precisely similar conditions for the period of one year. The color of all the metals altered in the lapse of time. The aluminium lost its luster, and became of a dead, bluish-gray color; the German silver also degenerated to a grayish-yellow tint; the silver lost only in color, its luster was not impaired. As regards mechanical abrasion, no marked difference was perceptible, although after a year's use the aluminium spoon showed marked traces of wear at the edges. By accurately weighing the spoons at the end of the period named, Herr Winkler was enabled to establish the fact that the loss of weight suffered by the spoon of silver was 0·403 per cent.; by the aluminium spoon, 0·630 per cent.; and by that of German silver, 1·006 per cent. From this fact it appears that the assertion that aluminium is unsuited to sustain wear is not borne out. Upon the question of the adaptation of aluminium for coinage, Herr Winkler expresses a favorable opinion—so far as the wearing properties of the metal are concerned—and affirms that for small coins it is to be preferred to nickel or silver alloys.—*Engineer.*

PREPARATION OF ANTHRAQUINON BY THE ACTION OF CHLORIDE OF LIME AND A METALLIC SALT UPON ANTHRACEN.—M. A. Henniges.—On mixing anthracen with manganous chloride and chloride of lime there is precipitated manganic oxide, which oxidizes the anthracen to anthraquinon. In three hours the reaction is complete; the manganese is removed by means of an acid, and the anthraquinon is purified by sublimation. But it still contains 18 per cent. of chlorine. If chloride of platinum is used instead of that of manganese, the product contains 12·25 per cent. of chlorine, and if chlorine of cobalt be employed we find merely 2 per cent. The chlorine thus present is not combined with the anthraquinon, but belongs to a secondary product. Certain metallic salts convert anthracen directly into anthraquinon. We obtain the latter compound by moistening with water a mixture of equal parts of anthracen and ferric chloride, heating to 100°, and adding from time to time a little water. After twenty-four hours the product is washed with acidulated water, which leaves crude anthraquinon. Thus 100 grms. of sublimed anthracen gave 116 grms. of crude anthraquinon, which latter yielded 9·6 grms of sublimed anthraquinon. Nitrate of iron acts in an analogous manner, 10 grms. of anthracen producing 3 grms. of sublimed anthraquinon. Lastly, the author arrived at the same result by digesting the anthracen with peroxide of manganese and sulphuric acid, diluted with an equal volume of water. The reaction begins spontaneously, but it requires to be completed by keeping the mixture in the water-bath. The product thus obtained is purer and more abundant than that yielded by the methods previously mentioned.—*Dingler's Journal.*

ZINC IN ANIMALS AND VEGETABLES.—MM. G. Lechartier and F. Bellamy.—The authors first succeeded in detecting zinc in the livers of various men of different occupations and who had died of different diseases. They recognized the same metal in the muscles of an ox, in the liver of a calf, and in the eggs of the common fowl. Lastly, zinc was discovered in wheat, maize, barley, winter tares, white Neapolitan haricots, beet-root, etc. The reagents employed were subjected to a careful examination and found free from zinc.—*Comptes Rendus.*

EFFECT OF ACIDS UPON VEGETABLE AND ANIMAL FIBRE.—M. J. Weissner.—The author shows that vegetable fibre (mixed, *e.g.*, with wool) may be completely destroyed by steeping for an hour in water containing from 1 to 2 per cent. of sulphuric acid, and subsequent exposure to a temperature of 50° to 60°. Animal fibre, on the contrary, is strengthened by a similar treatment with water containing from 3 to 4 or 5 per cent. of acid, and subsequent exposure to a heat of 60° to 65°. If the acid liquid is stronger, containing 7 or 8 per cent., the fibre is weakened.

SIDERAPHTHITE is the name given to a new alloy composed of 66 parts of iron, 23 of nickel, 4 of tungsten, 5 of aluminium, and 5 of copper. It is said to resist sulphuretted hydrogen and the vegetable acids, and to be but slightly attacked by mineral acids. It is really more useful than silver, and can be prepared at less cost than German silver.

THE JOYOTE OF MEXICO.

By PROFESSOR ALFONSO HERRERA, Member of the Mexican Society of Natural History.

IN the damp, hot regions of the fertile mountains of the great Mexican Cordillera grows a tree remarkable for its thick foliage, elegance and beauty of its golden colored flowers, and the uncommon form of its fruit. The Aztecs called it *Joyotli*, hawks-bell, on account of the use they made of the nuts as bells, but others say that it takes its name from the property of the seeds to cure the bite of the Crotalus, rattlesnake; and the wise physician, Felipe II., says: "The ancient Mexicans made use of the milky juice that the tree produces in abundance, for curing deafness and cutaneous diseases. They applied the leaves topically in toothache, and as an emollient and resolvent to tumors, and lastly, they used the fruit to heal ulcers."

At present the fruit is called huesos ó codos de fraile, bones of friar's elbow, perhaps for its resemblance to the human elbow. Among the people these seeds have a great reputation in hemorrhoids, and are applied topically after being triturated and mixed with suet.

The excessive acrimony of the seeds of the joyote attracted my attention, and induced me to investigate them. The small quantity at my disposal and other circumstances have prevented a fuller investigation, but incomplete as it may be, it may well serve as a basis for further observations.

The seeds of the joyote were conveniently divided, and by pressing in a common press, yielded 40 per cent. of oil resembling almond oil; its density at 20° C. is 0·9100; at 10° it becomes turbid, and at 0° C. it acquires the consistency of common lard. Concentrated sulphuric acid imparts a yellow, changing to rose color, and afterwards into deep orange-red; it is a non-drying oil, and appears to be composed of olein and palmitin. The residual powder was percolated with ether, and the liquid evaporated left a residue of about the same quantity as the oil previously obtained. Distilled water was afterwards used to extract albuminous and extractive matters, and finally the exhausted substance was treated with 85 per cent. alcohol. The filtered liquid was evaporated expontaneously, and yielded a white substance, crystallizing in four-sided prisms. These crystals were inodorous, but excessively acrid, insoluble in water, and very little soluble in ether, bisulphide of carbon, fixed and volatile oils; but easily soluble in alcohol; not volatile, and not combining with acids or bases. When treated with dilute sulphuric acid, they decompose into glucose and a resinoid substance; the principle is, therefore, a glucoside. Its solution is not affected by nitrate of silver, the chlorides of platinum, gold or iron, iodide and iodate of potassium, tannin, potassa, ammonia, the alkaline carbonates, or by ferro- and ferrid cyanide of potassium. I propose to call it *thevetosin*, although *thevetin* would probably be a more appropriate name for this principle.

FROM LUIS HIDALGO CARPIO'S EXPERIMENTS.—1. That the thevetosin is very venomous. 2. That it has a violent emetic action depending upon the nervous system, like tartar. 3. That it acts on the respiration, making it difficult by paralysis, more and more complete on the external muscles of respiration. Judging from that, the tetanic convulsions followed by the clonical that preceded death, were the effects of asphyxia caused immediately from perlesia.

These experiments, made on different kinds of animals, prove that the emetic action of the different products of the joyote seeds is constant in all animals that can vomit; that the muscular system of respiration becomes paralytic, and that this paralysis can extend in some cases to the other muscles. Thevetosin, acting so powerfully upon the animal economy, may probably become of importance, and be employed more advantageously than curare.

XANTHIUM SPINOSUM.

DURING the past year the above plant has attracted some attention in Europe in consequence of its asserted prophylactic action against hydrophobia, and experiments were made with it in France with the view of testing its properties and virtues in that dreadful disease. That they have had a negative result has already been stated in our last volume (page 571); but since some inquiries for the new drug have been made in this country, and since the plant has been naturalized in various parts of the United States.

The genus Xanthium belongs to the natural order of Compositæ, tribe Senecionideæ, subtribe Melampodineæ, division Ambrosieæ of DeCandolle. It is characterized by having the staminate and pistillate flowers in different heads upon the same plant; the involucre of the former, which are placed at the top of the branches, is subglobose, consists of free scales placed in one row, and contains many florets with clavate, shortly five-lobed corollas. The pistillate heads have an oblong or ovoid involucre, which is closed, coriaceous, armed with hooked prickles and one or two strong beaks at the apex, and contains two florets with filiform corollas, no stamens and flat akenes destitute of pappus. The plants of this genus are all coarse-looking, annual weeds, with stout branching stems and alternate leaves, and are known by the trivial names of clot-weed and cocklebur.

The species under consideration was originally indigenous to the southern part of Europe, from Southern Russia west to France, but has gradually spread farther north into Hungary, Bohemia, Silesia, Switzerland, and Alsace, but in most places it occurs but sparingly, the farmers aiming at its extirpation on account of its rapidly spreading into the fields, to the great injury of the crops. It has likewise been to some extent introduced into most civilized countries, and in the United States is found spontaneous and completely naturalized in the eastern section from the New England States south to Georgia, growing in waste places and neglected fields, near the seaboard and along rivers. Dr. W. Darlington, in his "Flora Ceatrica," 1853, strongly advocates its total extirpation, and states that "some years since the authorities of one of our cities, where it was becoming a great nuisance in the streets, enacted an ordinance against it, denouncing it by the name of *Canada thistle!*"

It produces a terete striate and pubescent stem, from one to three feet in height, and has lanceolate or ovate-lanceolate, shortly petiolate leaves, which are white downy beneath the lower being three-lobed, the upper more or less cut toothed or entire. At the base of each leaf are stipules, consisting of sharp, three forked, yellowish spines, frequently attaining an inch in length; the fertile burs are crowned with one short and inconspicuous beak. The leaves dried and powdered are of a green color, have a strong, somewhat narcotic odor and a bitter taste. According to C. C. Keller, they contain a volatile oil and bitter extractive. The results of the analysis of Yvon and Nocard will be found in our last volume, page 538. The leaves were recommended to be taken uninterruptedly for six weeks in doses of 0·60 grams (10 grains) three times daily, for adults, and for children under 12 years, in half the quantity stated, cataplasms of the leaves being applied at the same time. For dogs, the doses required are said to be considerably larger. The drug is stated to be successfully employed in southern Russia, in cases of threatened hydrophobia.

A report on the action of Xanthium spinosum, by Trasbot and Nocard, was read December 14, 1876, before the Société Centrale de Médecine Vétérinaire. The authors had inoculated eleven dogs with saliva taken from a living rabid dog; six were treated with the leaves of xanthium, but nine of the whole number died in from fourteen to eighty days, two with all the symptoms of hydrophobia, the remainder with nervous symptoms, not decided enough to attribute them to this disease. The authors therefore conclude that the spinous cocklebur has not the property of curing hydrophobia, nor does it prevent its development, after either natural or experimental inoculation.

These experiments, it must be admitted, do not support the statements of Dr. Grzymala, of Podolia, who a year ago recommended it, based upon observations extending over twenty years, and numerous cases of men and animals bitten by rabid dogs or wolves. According to L. Ladé, it was noticed as early as 1861 by Oesterle, in his "Arzneimittellehre," as a remedy highly recommended by a Russian physician in hydrophobia. Other experiments are being made in the veterinary school of Zurich and very likely in other places, so that the true value of the proposed remedy will soon be established. Thus far it appears as if it was to share the fate of the *xanthion* of the ancient writers, the root, leaves and fruit of which were formerly held to possess diuretic diaphoretic and alterative properties.

The species alluded to is *Xanthium strumarium* Lin., which is now found in most parts of the civilized world, though perhaps originally indigenous to Asia, Europe and the northern part of Africa. It resembles the species above described, from which it is distinguished by the absence of spines at the base of the leaves, by the broadly ovate, somewhat trilobed leaves, and by the two-beaked burs. It is common in this country, particularly west. Closely allied to, and perhaps a mere variety of it, is the *X. echinatum, Murray*, which is mainly distinguished by its larger burs, and is found here near the seashore, in many places of Mexico, South America and the Old World. *X. indicum, Roxb.*, which is found from China and India west to Egypt, is likewise very similar to it. Evidently distinct is *X. catharticum*, H. B. K., of Ecuador, with ternate spines and pinnatifid leaves, which are hispid above and tomentose beneath. The herb is used in its native country as a cathartic under the name of *sasamaroucha*.—*American Journal of Pharmacy.*

BACTERIA, AND WHAT WILL KILL THEM.

IN the *Circular* of January last was an article upon "Bacteria by Prof. Tyndall, which presented a remarkable view of that microscopic vegetable in the production of the phenomena of fermentation. Below we present a short communication that appeared recently in the New York *Times*, which shows their wonderful tenacity of life, and what will not and what may destroy their vitality.

One of the most active and dangerous forms of bacteria, the micrococcus, is about the shape of the head of a small pin; or, rather, when magnified 800 times it looks like this: o o o o o. Another, the true bacteria, or rod-like particles, are about the following size and shape: ⊂⊃⊂⊃⊂⊃.

But the principal point is to find out what substances or medicines will destroy them. Quinine will not, for bacteria will live and flourish on a solution of twenty grains to two drachms of fluid. Nor will camphor, for they live on a solution of thirty grains in two teaspoonfuls of fluid. For five days they were seen swimming about among the pieces of camphor, and increasing immensely in numbers. Ten drops of carbolic acid in two drachms of fluid will not kill them. They also flourish in a solution of tar, and will swim about for six or more days between the particles of ten grains of calomel in two teaspoonfuls of fluid. One drachm of laudanum in two teaspoonfuls of fluid filled with bacteria will only commence to benumb and kill them at the end of six days.

They lived for ten days in a solution of tincture of nux vomica in two drachms of bacteria fluid. Tannin is the first remedy which has a decidedly destroying effect upon them. It will kill them in two hours; and although they will come to life again after being frozen in ice, and boiled in hot water, yet they will not do this after tannin is applied. Chloroform seems to kill them, but they will come to life again. They will live in a solution of one drachm of chloral in two of water. A concentrated solution of copperas, or sulphate of iron, will kill them; also chlorine water, and dilute muriatic, sulphuric, and nitric acids. We may draw the inferences that quinine, calomel, and carbolic acid are useless in diphtheria. That opium, nux vomica, chloroform, and chloral are comparatively so; and that tannin, sulphate of iron, chlorate of potash, chlorine water, and the dilute mineral acids may prove the only really useful remedies.—*Druggists' Circular.*

VEGETABLE COLORING MATTERS.

CHLOROPHYLL, *Fæcula viridis*, or leaf green, is the name generally given to the green coloring matter of vegetables; it is found in nearly all plants growing in the light, with the exception of fungi and the true parasites, covering either the cell-walls or the spiral bands, as in Spirogyra, or the granular contents of the cells, which are composed of starch, or other similar bodies. If plants that have been grown in the light are placed in the dark, the leaves fall; and if others are produced, they have a whitish color: again, if the plants that have been thus grown in the dark are removed to the light, the leaves soon lose their white hue, and eventually assume their natural color; the rapidity with which they become green, and the intensity of their color, will be in proportion to the amount of light to which they are exposed. The different rays of the spectrum have a varying influence in promoting the formation of chlorophyll, and some difference of opinion exists as to which rays are the most active in this respect, but the majority of experimenters agree that the yellow rays are those which are the most essential, because they have the greatest effect in promoting the decomposition of carbonic acid.

Mr. Fremy investigated the nature of this agent, and has ascertained that it is composed of two coloring principles, one a yellow, the other a blue; the former he has called phylloxanthin, and the latter phyllocyanin. Both these principles have been isolated by Mr. Fremy, who has also endeavored to show that the yellow color of blanched and very young leaves is due to the presence of a body which he has termed phylloxanthein, and which is colored blue by the vapor of acids. The same result occurs in the discoloration of phyllocyanin; hence it would seem that this phyllocyanin is not an immediate principle, but that it is formed by the alteration of phylloxanthein, and indeed the spectroscopic observations that have of late years been carried on in relation to this subject, I am sure I may say by Mr. Sorby, tend to show that chlorophyll is more complex than Mr. Fremy considered, as the substances he treats of were probably only products of decomposition by acids.

The various shades of green seen in the organs of plants depend upon very different causes; partly upon the nature of the chlorophyll, whether it is pure, or more or less mixed with the yellow, blue, or brown products of its decomposition—see Mr. Sorby's paper "On the Colors of Leaves at different Seasons of the Year;" partly upon the quantity of chlorophyll in the individual cells, partly on the thicker or looser arrangement of those cells, as on the under sides of leaves, which are generally of a lighter green, depending on the intercellular spaces which are there present, and which reflecting the light, white, thus mix with and diminish the intensity of the green.

When any form of chlorophyll is treated with ether or alcohol, the color is abstracted, while the organized forms, the corpuscles, etc., remain, so that true chlorophyll is really only a soluble substance, dyeing the bodies called chlorophyll granules, etc.; but the various degrees of solubility depend greatly on the presence of other substances, for instance, in the case of such evergreens as laurel, ether takes hardly any effect, but alcohol thoroughly discolors the leaves, whilst pyrethrum, a perennial, is hardly acted upon at all by alcohol, but ether takes great effect.

If these solutions are evaporated to dryness, under the exhausted receiver of an air-pump, a green fatty matter is left, which forms soaps in combination with the alkalies. If this is again dissolved in ether, and mixed with water, and the ether evaporated, small greasy globules are obtained, and similar globules are separated from the alcoholic solution at a freezing temperature. If the alcohol tincture be mixed with water, and the alcohol evaporated by heat, part of the fatty substance is precipitated; the remaining solution is colored a brown yellow, and has a characteristic smell, like that of black tea. It is soluble in the volatile and fixed oils, but when treated with sulphuric acid it is either not changed or else carbonized.

With regard to the second point or the coloring matter of plants, the green color, which forms the most extensive class, has been treated upon in our primary consideration on chlorophyll; the red and yellow colors, as assumed by the leaves in autumn, are due to a chemical metamorphosis of the chlorophyll, and consequently the discoloration of the cellular tissue—see also Mr. Sorby's paper "On the Various Tints of Autumnal Foliage.*" But independent of all this, there are the colors of the red cabbage, copper beech, and similar plants, all of which depend upon the existence of a special coloring liquid in the usually colorless epidermal cells, obscuring the chlorophyll which lies beneath. The bright colors of plants, and other parts of the inflorescence, as also on the lower surface of many leaves, *Begoniæ Victoriæ*, for instance, as well as numerous herbaceous shoots, arise from the presence of matters of a different kind, almost always dissolved in the watery cell-sap. The color of petals is ordinarily found to depend upon a certain number of the cells subjacent to the epidermal layer being filled with a colored fluid, and the depth of the color is proportionate to the number of superimposed layers of such cells, which act like so many layers of a pigment: each cell is usually filled with one color when fully developed, but adjacent cells are often seen in variegated petals to contain distinct colors, the line of demarcation being accurately fixed by the cell walls, through which the colors do not transude unless injured by pressure. In young tissues the color has often a granular appearance in the cells, but this is a deception, arising from the mode in which it is developed. The colorless protoplasm, originally filling the cells, becomes excavated as it were by water bubbles, and the watery contents of the excavations become colored; they gradually enlarge, as the protoplasm applies itself more completely to the walls of the cell, until they become confluent, and the colored liquid fills the whole cell cavity. The isolation of the colored juice in each particular cell seems to depend upon the primordial utricle, or parietal layer of protoplasm; when this is injured by pressure or other external causes, endosmose is set up, and the integrity of the cell destroyed. In some cases the liquid coloring matter of flowers has been found to contain solid corpuscles; the red color cells of *Salvia splendens* and the blue ones of *Strelitzia regina* contain globules, and according to Von Mohl this is still more commonly the case with the yellow colors. In the yellow, perigonal leaves of *Strelitzia regina*, the color is said to depend on the presence of crescentic filaments, floating in the cell sap; the white patches also on variegated and spotted leaves, such as those of Aucuba, Holly, variegated mint, Begonia, *Argyro stigma*, etc., arise from the absence of chlorophyll in the cells subjacent to the epidermis at those parts, which produces the same effect as we see in leaves that have been mined by caterpillars.

Now it follows that the coloring agent which is found in vegetables is in several states of combination; *first, with the extractive principle; secondly, with the resinous principle;* and *thirdly, with a starchy or gummy principle*, and it is these states which indicate the means of extracting them.

Firstly, when, as in the case of logwood, madder, etc., the receptacle of the color is of the nature of extracts, water is capable of dissolving it.

Secondly, certain of the resinous coloring matters are soluble in alcohol, spirits of wine, or ether, and form in many cases the pharmaceutical tinctures: the other principle will be left, as it is hardly in connection with our subject.—T. PALMER, *Microscopical Journal.*

TANNIN.—Those who fear the destruction of our forests, resulting from the demand for hemlock bark, will take comfort in the success of attempts to obtain tannin from other sources. It has been estimated that one cord of hemlock bark produces one barrel of good tannin extract, worth $20. It is now said that one cord of alder will produce the same amount; and one ton of sweet fern gives of the best tannin $22 worth, besides a value of $7.50 in an inferior kind. There is said to be considerable activity in Hancock County, Me., in the new industry of extracting tannin from sweet fern.

THE Williams College Rocky Mountain natural history expedition will consist of about 20 students, and will start out July 9th, under Prof. Sanborn Tenny, in search of specimens, principally in the Salt Lake region, but stopping at Sherman, Saunders, Lake Como and Green River, to begin the collection.

* "Quart. Journal Sc." vol. i. p. 64.